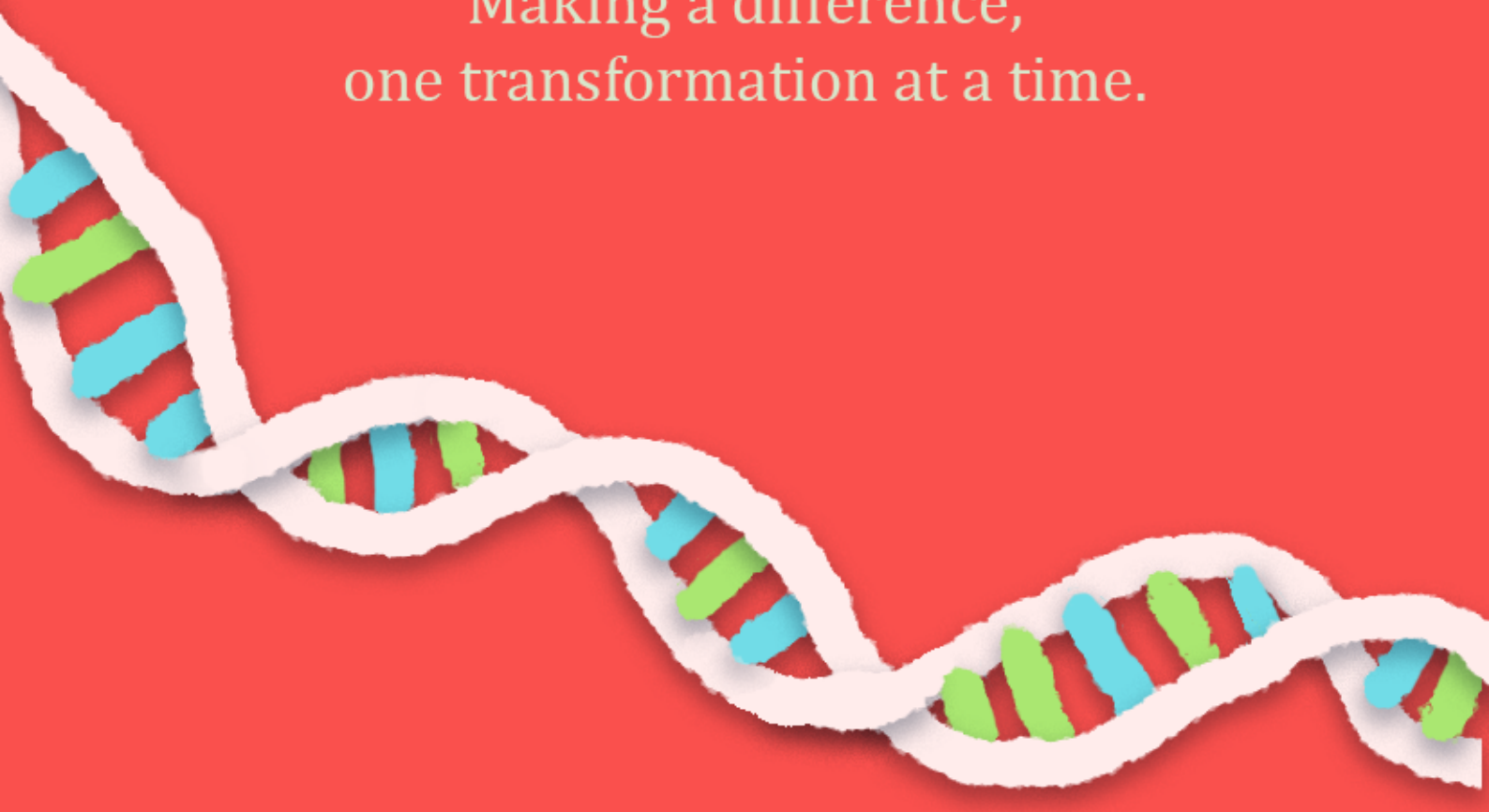
genos

Making a difference,
one transformation at a time.



An iGEM IISER Bhopal initiative

A Note from the iGEM Team

Dear Reader,

As an iGEM team from India, we truly understand the importance of exposure, education and opportunities. While iGEM is new on the Indian front, GENOS was our endeavor to bring this global world of synthetic biology to your doorstep.

There are breakthroughs happening in the world around us. In these times of disruptions, we wanted to show you, students, a glimpse of the disruptive progress in Synthetic Biology that is happening at an international scale and how iGEM is spearheading this revolution.

We decided to create GENOS, an e-Magazine with a cultural yet global narrative. With GENOS, we want to show you snippets of the coolest and most interesting synthetic biology research that is happening as you read this magazine. But more importantly, we wanted to bring out the individuality and personal connection that you create with each writer, blogger, artist, and videographer who has contributed to this magazine. Introductions to each article in regional languages from each contributor are to show you the diversity of our team and you can be one of us.

We are regular individuals just like you, and we hope that our synthetic biology stories inspire you as much your presence has inspired us to create GENOS.

Enjoy the read!

Cheers!!

Team iGEM IISER Bhopal 2020

Illuminating Life

At times, dark backdrops inspire bright lights

निसर्गाने अनेक रहस्ये ठेवली आहेत. त्यातील एक बायोल्युमिनेसेन्स म्हणून ओळखली जाणारी एक घटना आहे. हे असंख्य स्थलीय आणि सागरी जीवांमध्ये आढळते आणि खरोखर एक आश्चर्यकारक घटना आहे. बायोलिमाइन्सन्सची कारणे असंख्य आहेत आणि तितकीच मनोरंजक देखील आहेत. हा लेख त्यामागील विज्ञान, त्याची कारणे आणि त्यातील विविध अनुप्रयोगांचे वर्णन करतो.

Nature's Fireworks

It's June. You're in a North American temperate forest, strolling through damp Tennessee woodlands enjoying the warm summer evening. Away from all urban qualms and artificial lights. The surrounding is humid, and the temperature is just right for one of nature's most flamboyant wonders to be showcased. The night goes haywire with seemingly chaotic little light bulbs flashing as though short bursts of miniature fireworks tantalizing you.

Fireflies

It's hard to believe that every species has its own distinctive flashing patterns and it's hard to fathom the reason for this complex ordeal of pyrotechnic display and coordination. This entire snafu is just an old mating ritual. Often, flying firefly males flash to attract mates, some species doing so synchronously, a capacity called 'entraining' which means responding to an external rhythm. Flashing is done to attract stationary females who may flash the same signal back to the one they find someone interesting, after which the male waits for precisely 4 seconds and flashes again. If the female flashes back the same signal yet again, the male knows that he's welcome to proceed. From a female firefly point of view, for an initial assessment, along with the precise timing of flashing and the pattern of flight whilst flashing, the brighter the flash and the longer it lasts, the better the quality of genes possessed by the male and the greater is his chance of mating with her.

Fuel For The Explosions

Also known as lightning bugs, fireflies are not actually flies, but beetles belonging to the species Lampyridae. The secret behind their 'cold light', as it is called, is an enzyme called luciferase, which catalyzes the reaction between a protein called luciferin, and oxygen. Energy in the form of of a photon is emitted when luciferin and oxygen react to form oxyluciferin. In some organisms instead of the enzyme luciferase a photoprotein is used to aid this reaction. Photoproteins were first studied in bioluminescent crystal jellyfish found off the west coast of North America. The photoprotein in crystal jellyfish is called 'Green Fluorescent Protein' or GFP. GFP is an extremely important molecule in imaging studies. Photoproteins combine with luciferins and oxygen, but need another agent, often an ion of the element calcium, to produce light.

> "The fluorescing light is only visible in the presence of the stimulating light."

Bioluminescence

The overarching term for such and other related phenomena is 'Bioluminescence'. It is a form of chemiluminescence, which means that light is produced by means of a

Fireflies in Tennessee

chemical reaction. Bioluminescence is at times autogenic meaning self-generated by the organism though most of the times it has something to do with the symbiotic relationship between the host organism and the bacteria sheltered within the host's body. In some organisms, it is set according to the organism's circadian rhythm which is a body's natural 24-hour clock of sleep and wakefulness. Closely related terms are often used interchangeably by some folks and that can lead to murky understanding of concepts. To shed light, bioluminescence is different from fluorescence in that it involves a chemical reaction. The fluorescing light is only visible in the presence of the stimulating light. This is exhibited by some coral reefs, swell sharks, sea turtles, algae, bird feathers, vitamin B and even your own fingernails!

The phenomenon may seem pretty rare at the first glance. The only thing we have to do is to delve a bit deeper. Here outside our comfort zones, in the deep seas and oceans, a whopping 76% marine animals are bioluminescent. At least 1500 species of fish are known to be bioluminescent. On land too, more than 90 percent fungi glow in the dark.

Reasons for Bioluminescence

Now, what's the reason for this wonder? Is all of this just for mating? Are the circling flashes of Atolla jellyfish or the rippling, sparkly waves of Bareo comb jellies just to put on a show?

Turs out an organism may emit light for a variety of reasons: To attract mates, To fend off predators, To lure prey, To camouflage, As a decoy, To surprise or delay, As deception in the form of mimicry and To confuse the predator

As per the adage "The enemy of my enemy is my friend", bioluminescence may serve to summon the predator of the predator. Known as the "burglar alarm" effect, this may be especially important for tiny life-forms, such as dinoflagellates, that cannot swim fast. The chief defence for these creatures is not fight or flight — but light.

Why does Marine Bioluminescence Predominate?

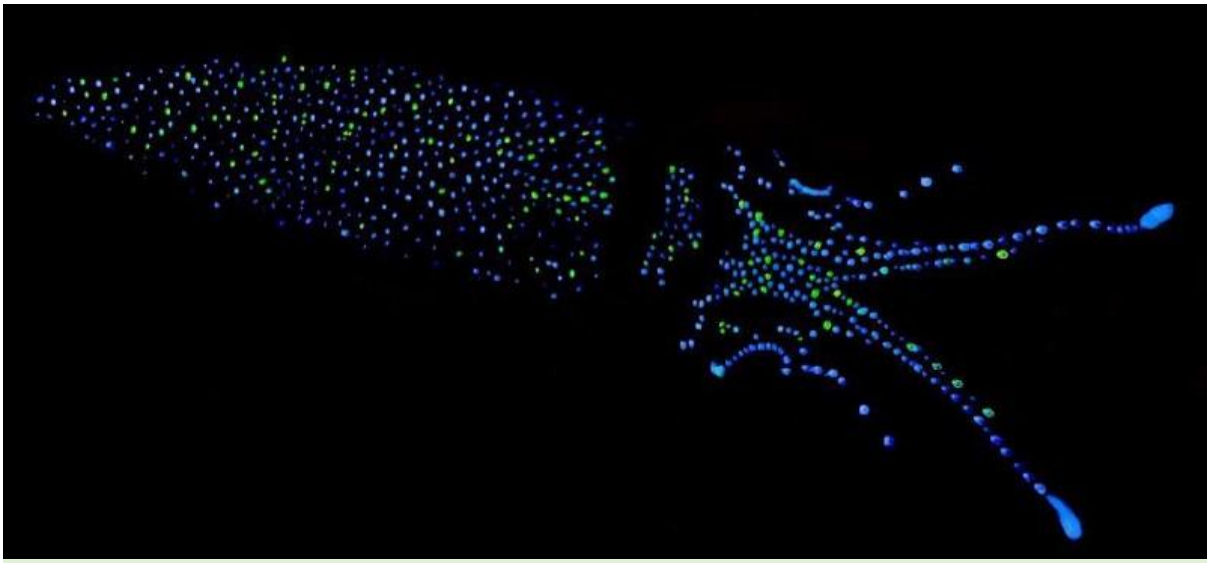
Studies point out the fact that bioluminescence is mostly observed in marine biomes. Why is that so?

Well, most scientists point to two reasons for the dearth of freshwater organisms exhibiting bioluminescenc. First, freshwater habitats have not been around as long as marine habitats — evolution is a slow process and freshwater habitats do not yet have the biodiversity of oceans. According to studies, very few bioluminescent fish can tolerate low salinity, as of now. Evolution can indeed be a really long process. Second, freshwater species wouldn't really benefit from bioluminescence. Freshwater habitats are often murkier, and deep-water species use other adaptations (such as a catfish's sensitive 'whiskers') to hunt and defend in the environment.

The only instance of bioluminescence in a freshwater animal is Latia neritoides, a limpet (marine mollusk often found clinging to rocks)-like snail native to New-Zealand's streams, where it emits a glowing slime when bothered.

Applications Of Bioluminescence

The applications of bioluminescence are as



Firefly Squid exhibiting bioluminiscence

diverse as the plethora of creatures which possess it.

GFP (Green Florescent Protein) found in the bioluminescent jelly fish Aequorea Victoria, is an excellent 'reporter gene'. It is able to attach itself to another gene without interfering with the gene's natural behaviour. This allows scientists to trace and monitor the activity of the studied gene;its expression in a cell, or its interaction with other chemicals. GFP emits light by a process called as 'resonant energy transfer'. This process basically converts the blue light released by aequorin (a type of photoprotein) or even ultraviolet light, into green light. Bioluminescent trees, Luciferase-based systems & Bioluminescent activated destruction are a few more

The Limitless Potential Of Bioluminescence

Now that we have metaphorically and literally noticed the sheer usefulness of this unique phenomenon, the future researchers have much to look forward to. Imagine a deep-sea squid squirting nebulous light in our direction before darting in the gloom. We have found this ethereal phenomenon and the direction before us is blurred. Now imagine tiny ostracods releasing flash bombs before us, which yield one of the brightest of lights to be emitted by any living being. Hence, we are also blinded by the endless possibilities we can sculpt this to our advantage and to the advancement of research of the upcoming years.

Ranging from poignant Darwin snippets to the research for detecting and hiding submarines by the US navy during the cold war, bioluminescence has indeed come a long way, arising in more than 50 independent species while treading along the thorny path of evolution. There's a whole new world to explore still. Pyrosomes, red scorpionfish, green bombers and many others are equally fascinating organisms and I do implore you to explore this coruscating cosmos. More than 95% of the ocean is yet to be discovered and species are already drastically on the decline as witnessed never before. Our actions affect this once teeming life in ways we can't even begin to comprehend. What we know currently know might just be a tiny flash of light in the vast wilderness of myriad fireflies, heralding the beacon light for future generations to come.

- Amey Danole

A Revolution Delayed: Viral Vectors in Gene Therapy

வைரஸ் திசையன்கள், கடந்த சில தசாப்தங்களாக, மனித ஹோஸ்ட்களில் வெளிநாட்டு டி.என்.ஏவை வழங்குவதற்கான ஒரு புதிரான முறையாக உருவெடுத்துள்ளன. இருப்பினும், வைரஸ் மரபணு சிகிச்சையின் துறையானது 2000 களின் முற்பகுதியில் கடுமையான பின்னடைவுகளை சந்தித்தது, ஏனெனில் அவற்றின் பாதுகாப்பு குறித்த கவலைகள் தெளிவாகத் தெரிந்தன. கடந்த தசாப்தத்தில், விஞ்ஞான சமூகம் அந்த சிக்கல்களை சரிசெய்ய அயராது உழைத்து, ஒரு புதிய வைரஸ் புரட்சிக்கு வழி வகுத்தது.

With the world in midst of a deadly viral pandemic, it can be hard to picture a world where viruses are thought of as our saviors. Yet, mere decades ago, stories of viruses swooping in to eradicate diseases and revolutionize medicine lit up the world. For years it was thought that viral gene therapy was the revolution that never was. It may appear to some that their initial promise has since faded: leaving behind nothing but a bitter taste in our mouths. But the long, tumultuous history of viral gene therapy has taught us lessons that may yet light our way towards a safer future.

> “...with the lessons we’ve learned, and with the rise of gene editing techniques like the much heralded CRISPR-Cas system, there might just be light at the end of the tunnel.”

It started in 1972 with a speculative paper in the journal Science that suggested the possibility of using viruses as ‘vectors’, or, put simply, vehicles, to deliver DNA fragments of our choice into human cells. Viruses, as it had become apparent, had mastered the black art of gene editing far before we did. Forged in the fires of natural selection, they are experts at enslaving our cells to suit their purposes. Some argued that we could bend them to our will; that we could simply add fresh bits of DNA to their genomes, and they would do all the heavy lifting of getting it into our cells to do our bidding.

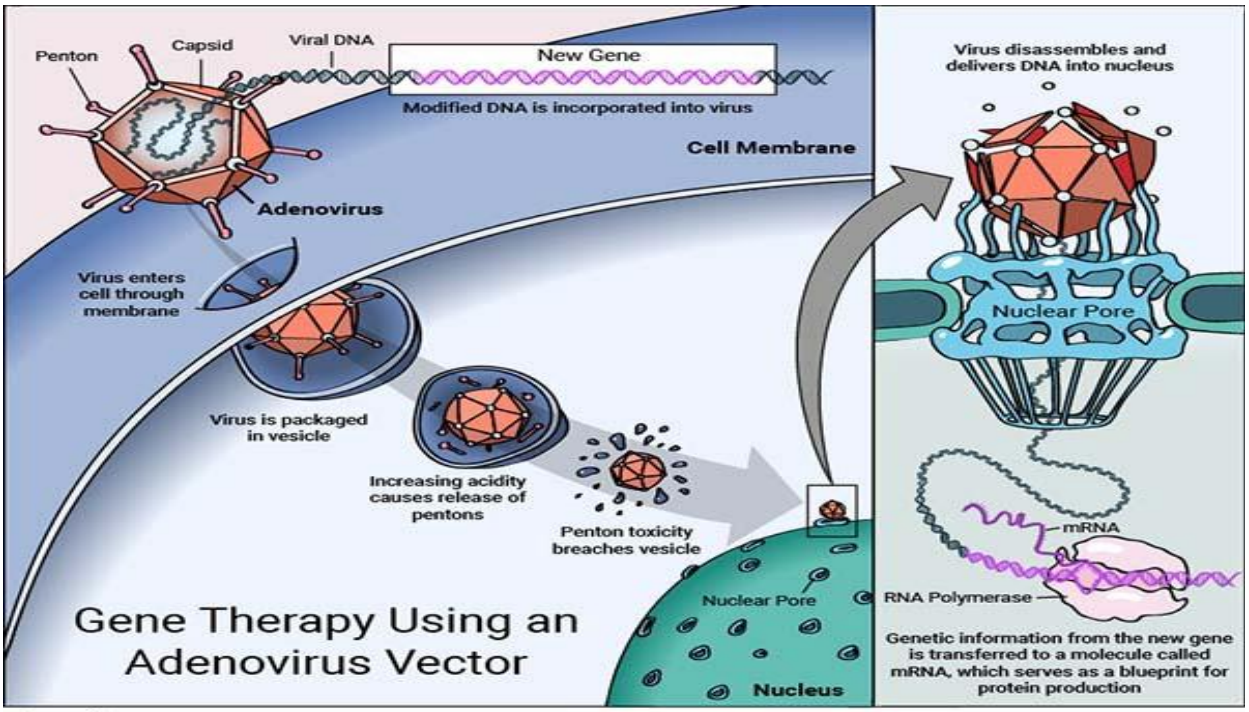
Close to two decades of toil later, in 1990, a four-year-old girl with a debilitating defect in her immune system was successfully treated with a retroviral vector, a gene therapy method that helped her body produce a crucial enzyme. It sparked a decade of feverish excitement over gene therapy, with new clinical trials being approved left and right, and headlines predicting a new age of medicine. We were on the precipice of greatness.

And then disaster struck.

His name was Jesse Gelsinger. He suffered from a rare metabolic disorder that researchers tried to remedy with a gene on an adenoviral vector. Tragically, the virus triggered a severe immune response, killing him in days.

That tragedy, coupled with a 2008 case involving four patients contracting leukemia following retroviral gene therapy jolted a seemingly mortal blow to the field of gene therapy.

Slowly but surely, however, the scientific community learned from its failures. It soon came to light that adenoviral vectors elicited particularly strong immune responses, explaining Jesse’s death. Retroviral vectors, such as the ones involved in the 2008 study, are associated with a phenomenon called ‘insertional mutagenesis’. Retroviruses insert their genomes into random locations in our chromosomes, and some of them, by chance, insert themselves into or around some of our genes, including potentially anti-cancer safeguards called tumor suppressors, causing mutations and paving



the way for a tumor to take root.

Biologists have found workarounds to these issues by developing new vectors based on different viruses. The vectors that dominate the field of gene therapy today are based on adeno-associated viruses (AAVs). They're non-replicating, non-pathogenic viruses that our immune system tends to ignore. They can also infect a wide variety of cells, and AAV- delivered DNA persists in cells for a long time, making them more suited to long term use. They represent a significant improvement over adenoviruses, but they come with their fair share of flaws. For instance, much like retroviral vectors, the use of AAV vectors is often associated with chromosomal integration, bringing with it the risk of insertional mutagenesis (although this risk appears to be far lower than with retroviruses).

Perhaps more importantly, they are prohibitively small. They can only take in up to 5,000 bases of DNA, barely enough for a single gene, or two, at most. While that's enough to be useful in certain contexts, scientists prefer a greater degree of flexibility.

Enter the herpes simplex virus (HSV-1, to be specific). The causative agent of oral herpes has attracted quite a lot of interest as a potential vector backbone. It has a much bigger trunk, with a capacity of close to 50,000 bases, it's infamous for its ability to sneak past our immune system undetected, and, crucially, the DNA it delivers into cells forms what's known as an 'episome'; a stable, circularized DNA molecule that doesn't get into our chromosomes, greatly reducing the risks of insertional mutagenesis. Its frequency to cause disease is an obvious point of concern, but that's being dealt with as well, with engineers working to strip out the parts of it associated with disease phenotypes.

To be sure, several kinks remain to be worked out. Precious few human gene therapeutics have received the regulatory green light anywhere in the world, and there is certainly replication work to be done with regard to safety and efficiency. But, with the lessons we've learned, and with the rise of gene editing techniques like the much-heralded CRISPR-Cas system, there might just be light at the end of the tunnel.

- Shashaank G

BioMachines That Can Sense The Environment

बायोसेंसर उपकरणों में उपयोग किए जाने वाले इलेक्ट्रॉनिक सेंसर की तरह हैं लेकिन प्रमुख रूप से जैविक भागों से मिलकर बने होते हैं। बायोसेंसर्स एनालेट, बायोरिसेप्टर, ट्रान्सड्यूसर, एनालिटिक्स इलेक्ट्रॉनिक्स और डिस्प्ले से बने होते हैं। पूरे-सेल बायोसेंसर विश्लेषण को पहचानने के लिए जीवित कोशिकाओं का उपयोग करते हैं। इन सेंसरों में उच्च क्षमता होती है और वे अधिक आशाजनक हो जाते हैं, जब आनुवंशिक रूप से संशोधित कोशिकाओं का उपयोग बायोरोकॉग्निशन तत्व के रूप में किया जाता है।

Biosensors are like electronic sensors used in devices but majorly consist of biological parts. They can be distinguished by specific components depending on the substance they are used to detect. A biosensor works like a smoke alarm which goes off in the presence of biologically significant 'analytes'.

Leland C. Clark, the 'Father of Biosensors', developed the first biosensor to detect oxygen. Nowadays, they are used to detect methane, nitrogen or even the amount of stress (reactive oxygen species) in the human body.

A typical biosensor has the following parts:

> "These devices have great potential and researchers are trying to enhance them using synthetic biology...."

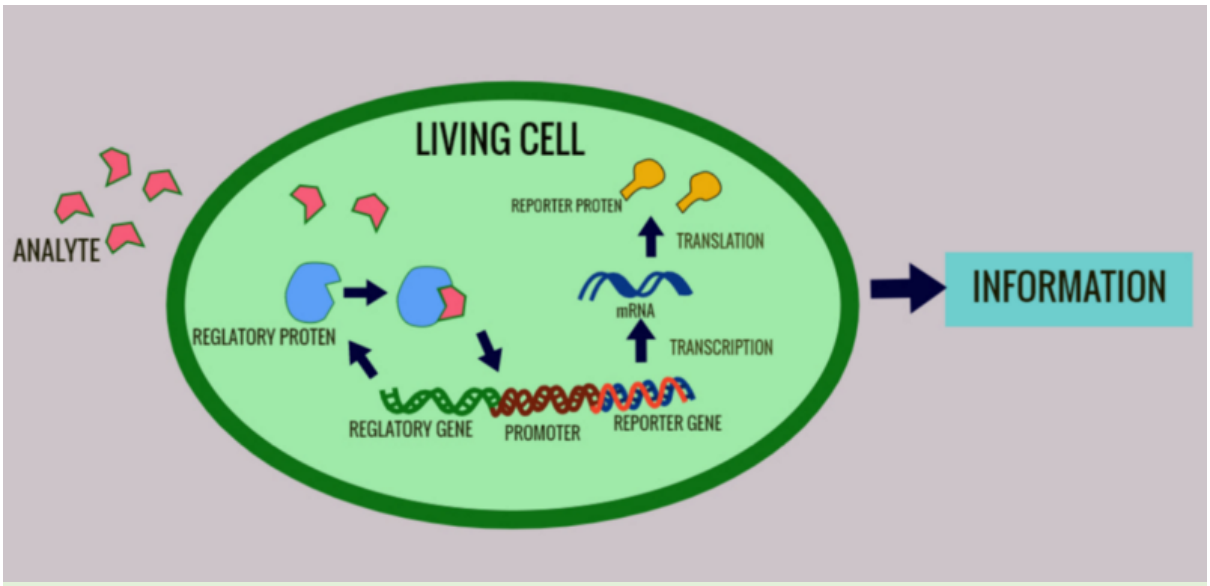
1. **Analyte:** The substance we want to detect — for example, methane.
2. **Bioreceptor:** This molecule is like a sniffer dog that recognizes our analyte of interest
3. **Transducer:** It helps create a recognition signal upon the detection of the analyte. This process is called 'signalization'.
4. **Analyte Electronics:** This processes the transduced signal and prepares it for display. The processed signal is then computed for display.
5. **Display:** This part of the sensor consists of hardware and software. It works like a computer display that shows us the processed data.

Whole-cell biosensors

Whole-cell biosensors use living cells as the sensor and can recognize a broader range of "analytes" with higher sensitivity.

They are used to obtain useful information on the effect of a stimulus on a living body and help us observe variations easily. These changes in the organism, once discovered, can be used in future experiments, offering better sensitivity. So if you contract a gastric infection, the cell biosensors can tell precisely what is wrong in the gut and how that can be fixed. The most commercially successful whole-cell biosensors till date are toxicity sensors based on bacteria that are naturally luminescent in the dark such as *Vibrio harveyi, Vibrio* (Photobacterium) *fischeri*, and *Photobacterium phosphoreum*. In these cases, light is produced continuously by the action of a luminescence gene (LuxAB), so any toxic substance that interferes with the bacteria's metabolism will reduce this light emission. This attenuation can be detected using a luminometer (a device to detect light intensity). However, these sensors are not very specific and are only useful for preliminary screening of toxins in the environment.

Whole-cell biosensors have a very high potential, and it becomes more promising when genetically modified cells are used for recognizing anomalies in the environment.



A schematic showing a typical whole-cell biosensor

The fascinating aspect of synthetic biology is the modifications made in the genes of a micro-organism. It includes applying engineering principles to biology to get the desired biological changes.

Since whole-cell biosensors consist of a biorecognition element along with a chosen reporter, synthetic biology is perfectly suited for advancement of these sensors. To validate the potential of this approach to synthetic biology, the iGEM (International genetically engineered machine) competition was established in 2005. The first project based on biosensors submitted to iGEM was in 2006 by the team from the University of Edinburgh which was an arsenic biosensor which could be used to detect arsenic in developing countries, a toxin that can lead to shock, cancer or even death. Another example of an iGEM project is the methane biosensor, "MethNote', developed by the team from IISER Bhopal in 2018 to improve the environmental monitoring of methane.

Synthetic biology has helped other biosensors to develop as well. For example, nanotube biosensors developed by researchers, using synthetic biology has improved their sensing capabilities in the complex biofluids. This system is made up of nanotubes wrapped by Xeno nucleic acids (XNA) or the synthetic DNA that can tolerate changes in salt concentration in our bodies, to relay stable signals.

Biosensors are widely used in disease diagnosis and various other fields, including research. These devices require the interaction of different disciplines of science and technology. The biosensors used today have evolved with enhanced selectivity, reproducibility, stability, sensitivity and linearity, resulting in better experimental outcomes for research purposes. Whole-cell biosensors are the biosensors that offer a versatile and widely applicable method for detecting the presence of the analytes. These devices have great potential and researchers are trying to enhance them using synthetic biology which offers numerous possible improvements in terms of response tuning, signal processing, and direct interface with electronic devices for further signal processing and output.

- Anurag Yadav

An Introduction to the Common Types of Cancer

癌症，或者说恶性肿瘤，可以根据组织起源，发生部位，生长速度，侵袭性大小，和病理角度等来进行分类。这片文章将介绍最长见的几种癌症：肺癌（非小细胞肺癌和小细胞肺癌）、结肠癌、肝癌、和乳腺癌。

What are cancers ? How are they classified? Cancers are malignancies that can be classified based on the following : tissue origin, site of occurrence, growth rate, invasive size, and pathology. This article will introduce certain types of cancers with high occurrence rates.

Lung cancer, a cancer with two subtypes, is the cancer with the highest occurrence rate. About 85 percent of these cases are non-small cell lung cancer, the rest being small cell lung cancer. As their names imply, non-small cell lung cancer refers to types of lung cancer where tumor cells are larger; in the latter, the cells which make up the tumor are much smaller. In addition, NSCLC develops much more slowly than SCLC. Without seeking treatment, the survival of patients with small-cell lung cancer is estimated to be between two to four months. On the other hand, non-small-cell lung cancer patients may survive for up to seven months. The five-year survival rate for those with small-cell lung cancer is only 5 to 10 percent, while it is 24 percent for those with non-small-cell lung cancer.

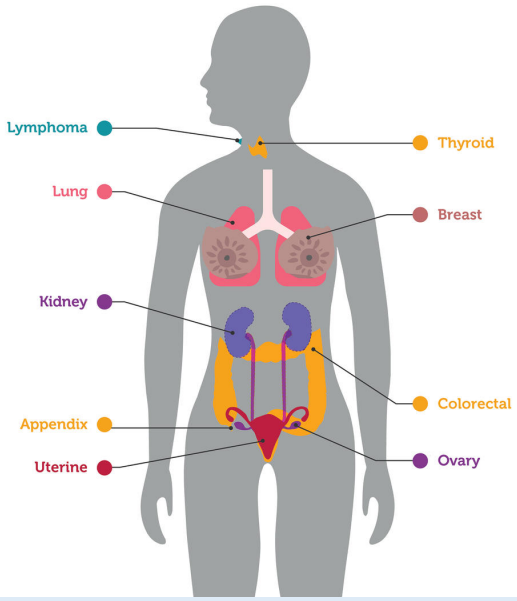
The second most commonly occurring cancer is colon cancer, a common gastrointestinal malignancy occurring in the colon, usually at the junction of the rectum and the sigmoid colon. It is largely prevalent between the age group of 40 and 50, with a ratio between 2:1 to 3:1 of males to females. The disease's cause is mainly related to a high fat and low fiber diet but is also affected by genetic factors. When there are signs of persistent abdominal pain, fecal blood or mucus, unexplained anemia, weight loss, etc., serious caution should be taken towards the possibility of colon cancer. Due to early symptoms being unobvious, careful examination is recommended. Early colon cancer can be treated with a minimally invasive endoscopy. However, in the middle and late stages, surgery, chemotherapy, immunotherapy, traditional Chinese medicine, and other therapies would not be helpful in the form of a combined treatment. The specific location of the malignancy would be taken into consideration while selecting the treatment(s).

> **“Lung cancer, a cancer with two subtypes, is the cancer with the highest occurrence rate.”**

Liver cancer ranks third in this hierarchy of prevalence and is divided into two kinds – primary and secondary. Primary liver malignancies originate from the epithelial or mesenchymal tissues of the liver. In contrast, secondary or metastatic liver cancers develop from multiple organ malignancies of the whole body and invade the liver. The occurrence of liver cancer is influenced by environmental and dietary factors, such as hepatitis B virus (HBV) and hepatitis C virus (HCV) infection, aflatoxin, contaminated drinking water, alcohol, liver cirrhosis, etc. Primary liver cancer often has symptoms such as pain in the liver area, abdominal distension, wasting, progressive largening of the liver, or mass in the upper abdomen. Secondary liver cancer has symptoms such as dull distention, discomfort or pain in the upper abdomen or liver area, fatigue, poor appetite, wasting, or

fever, but the signs are less severe than that of primary liver cancer. The commonly used therapies are surgery, chemotherapy, radiotherapy, biological therapy, and traditional Chinese medicine (TCM). The risk of developing liver cancer can be reduced by vaccinating against hepatitis B, being tested for hepatitis C, limiting alcohol consumption, and maintaining a healthy weight.

Breast cancer is the fourth most prevalent form of cancer and the most frequently occurring cancer among women. Breast cancer is a malignant tumor occurring in the epithelium of the breast. 99% of the cases of breast cancer occur in women and only 1% in men. Although in situ breast cancer is not fatal because the mammary gland is not a major organ, however due to the easy-shedding characteristic of cancer cells, it may spread throughout the body along with the blood, thus taking root in other vital organs and eventually endangering life. Risk factors include a family history of breast cancer, atypical hyperplasia of mammary glands, chest exposure to a high dose of radiation, long-term use of exogenous estrogen, long-term excessive drinking, and gene mutations associated with breast cancer – the BRCA mutation - 1, BRCA 2, p53 and PTEN, etc. Breast cancer may cause breast lumps, abnormal skin changes, and axillary lymph node swelling. At present, the treatment of breast cancer has entered the era of comprehensive treatment, forming a treatment mode that gives equal importance to local treatment as well as systemic treatment, the latter can adopt various means such as surgery, radiotherapy, chemotherapy, endocrine therapy, biologically targeted therapy, and TCM auxiliary therapy. Breast surgery includes breast-sparing surgery (breast-conserving surgery) and total mastectomy. Axillary lymph node surgery includes sentinel lymph node biopsy and axillary lymph node dissection. However, there are strict surgical requirements for breast preservation . In terms of prevention measures, here are a few ways:



Types of Cancer (Source: National Cancer Institute)

- Establish and maintain a good lifestyle;
- Exercise, socialize, and maintain the peace of mind;
- Actively treat breast diseases;
- Refrain from using exogenous estrogen;
- If female, screen for breast cancer.

This is the end of this article on Cancer Types. Thank you for reading to the end, and we hope you learned something new!

- Team iBowu China 2020

Saving Corals

White Cemeteries to Vibrant Kaleidoscopes

कोरल रीफ्स ही निसर्गाची सर्वात श्रीमंत परिसंस्था आहे. ते इतर असंख्य पर्यावरणीय प्रणाली टिकवून ठेवतात आणि आपण मानव देखील त्यांच्यावर जास्त अवलंबून असतो. हवामान बदल विशेषतः कोरल वर कठोर आहे. कोरल ब्लीचिंग म्हणून ओळखल्या जाणाऱ्या इंद्रियगोचरातून ते अक्षरशः मरत आहेत. हा लेख वर्णन करतो की कृत्रिम जीवशास्त्राच्या मदतीने आपण या विपुल समस्येचा सामना कसा करू शकतो.

Moonlit Euphoria

It's the fifth day after the full moon in November. At the Great Barrier Reef, moonlight streams silver all across the ocean surface sprawling an area roughly the size of Italy. The entire scene is lit up with the halo of the pearly white moon. This cold spring night awaits to witness a unique phenomenon. Underneath the water surface, nebulous white dots surrounded by ethereal clouds rise. They are coral gametes. As the eggs start going up, it looks almost like an eerie inverted underwater snowstorm. As thousands and thousands of colonies release their gametes synchronously once a year, the event is playfully dubbed as the 'Annual Sex Festival'.

> "Even though synthetic biology may be able to curb the issue now, the root of the problem persists."

Warm ocean waters suddenly team with trillions of eggs and sperm that swirl in the currents and merge to form new life, a profligate frenzy that can leave the ocean's surface awash in pink flotsam. These fuzzy spawners are affected by the tiniest of shifts in water temperature and bright light.

What exactly are corals?

Are they animals? Are the plants? Or are they inanimate rock structures? We'll start with polyps, the building blocks of corals.

Coral polyps are tiny pinhead size, soft-bodied organisms related to sea anemones and jellyfish. Each polyp has a mouth surrounded by tentacles, and a stomach. Millions of polyps fuse & combine to form one single organization known as a coral. It all starts from a single zygote which turns into a floating larva searching for the right spot on the seafloor to latch onto. Once settled down, it converts into a developing polyp which further divides asexually via fragmentation or budding, into several genetically identical clone polyps which ultimately combine to form a single mature coral. Thus, corals can reproduce sexually as well as asexually.

Now, these corals have been guided by evolution to have a symbiotic relationship with specific species of microalgae known as zooxanthellae. Having a symbiotic relationship or symbiosis, put in simple terms means that the coral and the microalgae sign a mutually beneficial contract stating that the microalgae will photosynthesize and provide essential nutrients such as sugars, amino acids, and oxygen to the coral. In turn, the coral will provide the microalgae with the required raw materials for photosynthesis such as carbon dioxide, which is a by-product of the coral's cellular respiration. Not stopping there, the contract also requires the microalgae to help the coral in removing its waste. In return the coral has to accept the zooxanthellae as tenants in its tissues and that too with a dense population of several

Coral spawning after sensing the full moon

million per square inch, providing safety in the form of an effective shelter. Because of this intimate relationship, corals respond to the environment just as plants do. Nighttime is when the polyps come into action. They come out of their skeleton and search for food, like floating particles of zooplankton and critters. Their long, stinging tentacles come in handy as they harpoon in their prey.

Corals are extremely sophisticated creatures but rather in a quiet, down to earth manner. They scourge for calcium carbonate in their surrounding water and manifest extraordinarily intricate, tall, exquisite, ornate and massive structures as their skeleton, which can even be seen from space! They're the architects of the reef megacities housing in quite a warming manner, the marine fauna which we all know to be an enormous and widespread cosmopolitan crowd, in their limitless edifices. They're like the rainforests of the oceanic ecosystems.

How do corals sense moonlight?

Do they see it visually? Or do they detect it somehow by the movement of tides? The answer lies in a 2007 study which confirmed that corals can tell when the full moon arrives with the help of an ancient gene that allows them to sense how much moonlight is hitting the water!

Where are coral reefs generally found and how do they form?

Corals require clear water so that sunlight can reach their algal cells for photosynthesis. For this very reason, they are generally found only in waters with small amounts of suspended material or water of low turbidity and low productivity.

Reefs form in one of three ways: First, they can be directly attached to the shore, as a 'fringing' reef. Second, they can be separated from the shore by a channel as a 'barrier' just like the world's most famous reef, the Great Barrier Reef. Third, they can be entirely separate from land in a ring shape or circle known as an 'atoll' which has a lagoon in its middle. They can form their islands.

Selfless Corals

Coral reefs are biodiversity hotspots of great ecological, economic, and aesthetic importance. Nearly 500 million people worldwide depend on them for their livelihoods. Along with contributing to a 6 Billion dollars tourism industry in Australia alone and employing over 70 thousand people there, coral reefs break storm waves, surges, erosion and hurricane damage. Many of today's islands exist because of their protection. They nurture a riot of marine species and fish stocks that feed millions of people. Covering only 0.0025 per cent of the ocean floor, they generate half of Earth's oxygen and absorb nearly a third of the carbon dioxide generated from fossil fuels. Also, biomedical compounds found in corals serve as potential cancer cures.

White Cemeteries

I'm sure many of us have encountered the term 'coral bleaching' time and again. Coral's most remarkable characteristic — being an animal that is part plant — is also its Achilles heel in a hotter world. Normally, coral polyps live in harmony with their algal partners, which help feed the polyps and give corals their bright colours. But during heat waves, the relationship sours and the contract is broken. Overheated polyps perceive the algae as an irritant and eject them like unwanted squatters. The coral is

left bleached, bone-white and starving. If the heat persists, and the coral still hasn't taken in new algae, it can die. The relentless rise of global temperatures is endangering coral reefs around the world.

The Silver Lining

In such dire circumstances, it's heartening to know that there are still glimmers of hope. We finally found ingenious ways to redeem our past mistakes. Armored with scientific creativity and an unparalleled display of mind and skills, we have finally found ways to tackle even this behemoth of an issue and ameliorate our present condition.

CRISPR To The Rescue

In attempts to understand corals' responses to stress and other aspects of their biology, numerous genomic and transcriptomic studies have been performed, generating a variety of hypotheses about the roles of genes and molecular pathways. Breaking genes to reveal the effects on the organism is a concept that's been the focal point of decades of molecular biology.

The powerful gene-editing tool CRISPR - Cas9 has taken the scientific world by storm. It gives researchers unique power and precision in making tweaks to practically any gene in a plant or animal and coral reefs have become its next beneficiary.

Phillip Cleves, PhD, a postdoctoral scholar at Stanford, is a geneticist whose efforts to delineate gene function in animals resides squarely within the marine invertebrate realm — namely, corals. Cleves is the lead author of the study which was first published on April 25, 2018, in the Proceedings of the National Academy of Sciences. Cleves and his team used CRISPR to edit three genes in corals growing in Australia's Great Barrier Reef. Two of the genes were responsible for the reef's coloring — coding for red and green fluorescent proteins — and one was involved in regulating how new coral settles and grows in a reef.

Some researchers want to try to dim the sun

Coral Bleaching in the Great Barrier Reef

over reefs by spreading a thin sun shield over the water or by spraying saltwater into clouds so that they reflect more sunlight. Others are looking at controlling coral spawn and steering it to reefs most in need. Some envision creating an entire aquaculture system — essentially coral farms — to raise handier strains, which could then be transplanted to ailing reefs.

Valid Trepidations

Genetically engineering corals to make them better able to withstand heat and resist bleaching is among the brightest of possibilities. But we can't help but concede that the idea will face resistance, like all proposals to release modified organisms into the environment. But that doesn't necessarily mean it should be shelved. Genetic engineering sure frightens people but in the coming 10 to 15 years, our current plight is projected to deteriorate at an alarming rate and the only viable alternative left inevitably will be synthetic biology and its tools.

All Drains Lead To The Ocean

This is just a start. We can wait for everyone to open their eyes and then take the matter seriously or start working towards the problem actively ourselves. That's what countless coral researchers and scientists did to achieve this current feat. Once a dreamlike kaleidoscope of life, color and movement now turned into a white cemetery. Even though synthetic biology may be able to curb the issue now, the root of the problem persists. We don't run around looking for a mop when we see a running tap overflowing; we close the tap first.

- Amey Danole

Can We Create Life using SynBio?

एक सजीव पेशी बऱ्याच निर्जीव रेणूने बनलेली असते. पेशींचे अनेक घटक असतात. आपण निर्जीव रेणू वापरून वेगवेगळे पेशींचे घटक बनवू शकतो. अशाप्रकारे आपण कृत्रिम जीवशास्त्र वापरुन निर्जीव रेणू पासून सजीव पेशी बनवू शकतो. कृत्रिम पेशी ही कृत्रिम जीवशास्त्राची एक सर्वोत्कृष्ट निर्मिती आहे. संशोधक ह्या कृत्रिम पेशी वापरून "ह्या विश्वात जीव कसे निर्माण झाले" हे सांगू शकतील. जर तुम्हाला हे जाणून घ्यायचं असेल, तर हे जरूर वाचा.

The cell is the basic functional and structural unit of all living organisms. It is often referred to as the 'building block of life.' Robert Hooke discovered the cell in 1665. Although the natural living cells have been on this planet for at least 3.5 billion years, scientists have made efforts and succeeded in synthesizing a cell synthetically. This article is about one of the recent developments in synthetic biology named synthetic cells. Let us start from basics about cells and develop the concept of artificial cells.

Let's explore if it is possible to make cells synthetically.

> "A synthetic cell is an engineered particle that mimics one or many functions of a biological cell."

The cell is the organization of many biomolecules (proteins, lipids, sugars, nucleic acids, etc.), organelles, and cytoplasm (which consists of water as its primary component) within a membrane. These are a lot of terminologies. Let's break the cell into its parts and read about them. It will help us to know the requirement to make cells artificially and create life.

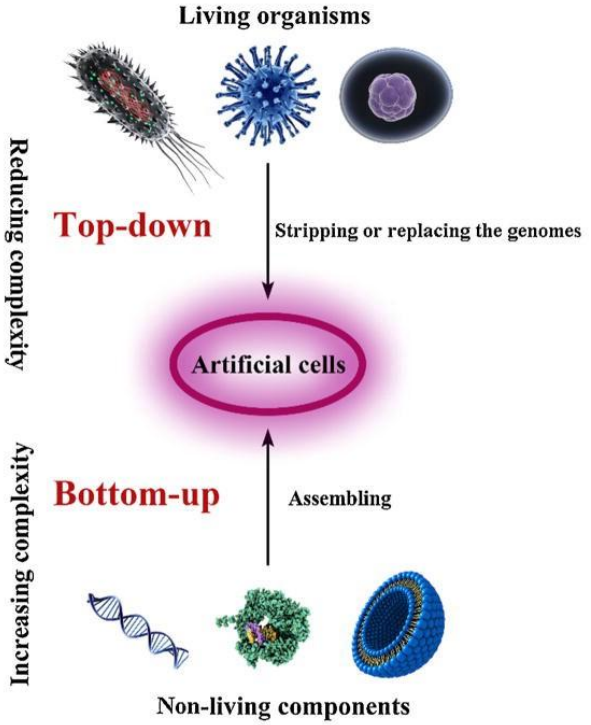
Components of cell

Like a fruit has layers around it to protect the material inside it, the cell has a layer called the cell membrane that protects it from its surroundings. The cell membrane consists of two layers of phospholipids and some proteins. The brain of the cell is the nucleus. It comprises of nucleic acids, proteins, and other biomolecules encapsulated in a membrane made of lipids (fats). The nucleus is the cell component that stores all the information related to the cell, its functioning, structure, etc.

Many parts of cells cannot function independently out of the cell but can be functional when they work collectively. Such elements of cells are called organelles. Scientifically, an organelle is a subcellular structure with one or more specific jobs to perform in the cell, much like an organ does in the body. Some important organelles are mitochondria, chloroplasts, endoplasmic reticulum, Golgi apparatus, etc.

What are synthetic cells?

A synthetic cell is an engineered particle that mimics one or many functions of a biological cell. The term does not refer to a specific physical entity but rather to the idea that certain functions or structures of biological cells can be replaced or supplemented with a synthetic entity. Thomas Chang developed the first artificial cells at McGill University in the 1960s. These cells consisted of ultrathin membranes of nylon, collodion, or crosslinked protein whose semipermeable properties allowed diffusion(random movement of particles) of small molecules in and out of the cell. These cells were micr-



Approaches for the design of artificial cells; Credits Xu et al.

on-sized and contained cell, enzymes, hemoglobin, magnetic materials, adsorbents, and proteins. These artificial cells can have applications in many fields, from medicine to the environment, and may be useful in constructing the theory of the origin of life.

The artificial cells can help us study the origin of life and develop a more accurate theory that supports it It is nearly difficult to remove some abundant or important molecules or proteins, which have been selected during evolution, from the natural cell. If the molecules, which were not chosen during evolution by nature, are introduced in artificial cells , it may help to study the reason for selecting a few molecules over others for a specific function. For example, we all know that ATP(Adenosine triphosphate) is the cell's energy currency. But in the cell, many other biomolecules have higher energy than ATP. Why has nature not chosen other biomolecules over ATP as the energy currency of the cell? Why was Adenosine Triphosphate (ATP) chosen over other triphosphates in the cell? All these questions may be answered by studying and researching synthetic cells.

How to make them?

There are mainly two methods to make synthetic cells:

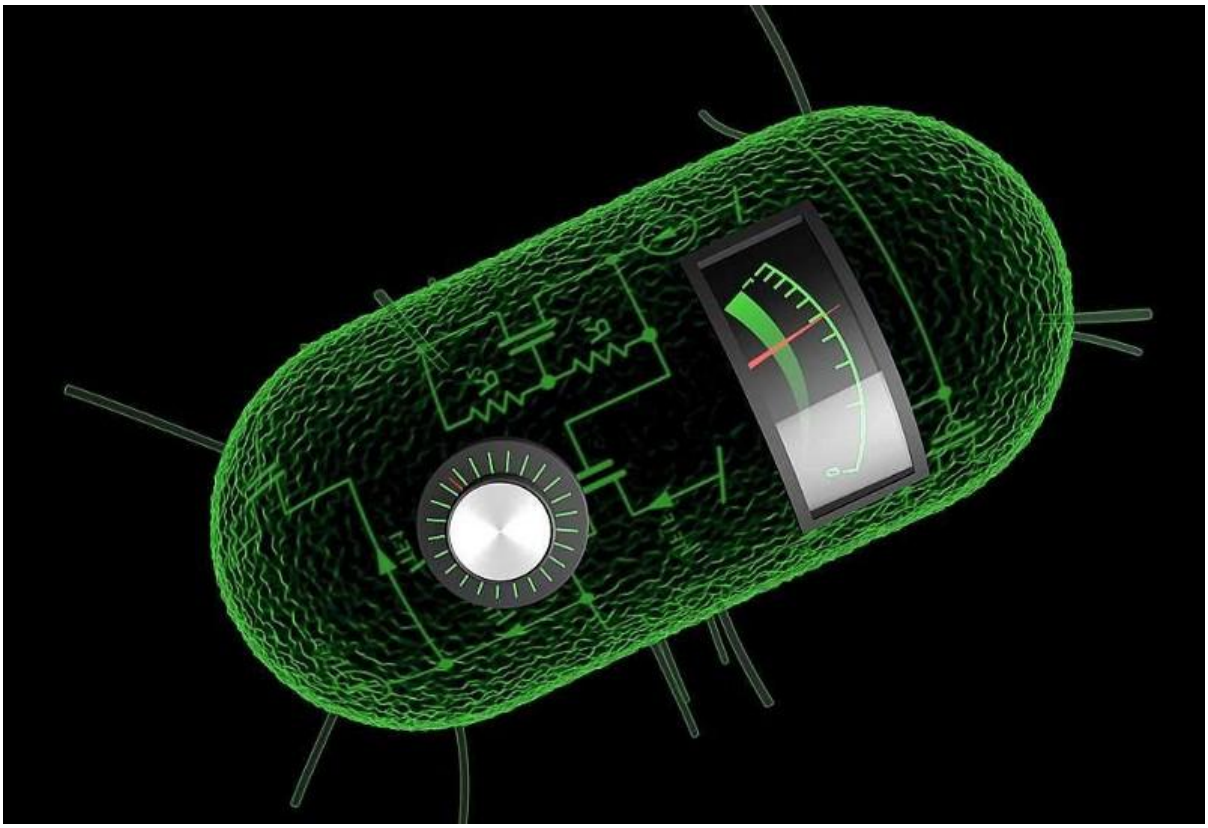
1. Top-Down Approach

In this method, the genome of the natural cell is removed from the nucleus. Then, the nucleus is filled with different combinations of genes. These cells are kept under observation and allowed to replicate. Some cells can survive, but some cannot. Scientists select the cells which can survive with a minimum amount of genetic material as artificial or synthetic cells for their research. So, natural cells can be modified to get artificial cells for a particular study. This method is called the top-down approach. Top refers to more complex cells with a complex genome. Then, we reduce the complexity of the genome and bring down the complexity of the cell.

2. Bottom-up approach

You might have guessed a bit about this approach after reading about the top-down approach. If not, don't worry. Let us understand the bottom-up approach. In this method, the bottom refers to the lowest level of complexity of the organization, i.e., fundamental biomolecules that form cells. Then the complexity of the cell is brought up from least complex biomolecules to artificial cells. In this approach, the biomolecules are organized to make complex artificial cells with minimum organelles, membranes, genome, etc. required for cells to survive. These parts are assembled to make artificial cells.

Experimentally, the bottom-up approach is more complex and challenging than the top-down approach to make synthetic cells. The bottom-up approach involves making the complete machinery of the cell from scratch unlike the top-down approach which is just modifying the readymade machinery to get appropriate useful synthetic cells. Although challenging, the bottom-up method is exten-



sively used to study the origin of life problem because the bottom-up approach allows us to remove and add desired molecules to the cell from scratch (initial stage). This helps in studying the evolution of cells and their components. Apart from these approaches, there are many other ways to make a cell using synthetic biology techniques.

Using synthetic biology, scientists successfully make a synthetic cell from scratch, i.e., non-biotic substances. We have created living things from non-living things. Do you think this method is feasible? Try to read this literature to know more about artificial or synthetic cells.

- Manas Joshi

Keeping Time

A dive into how organisms keep time & why it matters

चक्रीय घटनाओं को समझना और उन्हें उचित प्रतिक्रिया देना एक महत्वपूर्ण कार्य है जो सभी जीवों को दैनिक, मासिक या वार्षिक रूप से करना होगा। ये लय सभी यूकेरियोट्स, पौधों और यहां तक कि साइनोबैक्टीरिया में भी पाई गई है। बहुत महत्व और ब्याज सर्कैडियन लय हैं। इन्हें बाहरी लय के लिए मुक्त-रनिंग और सिंक्रोनाइज्ड के रूप में चित्रित किया जाता है। ये सर्वव्यापी लय बदले में कैंसर, मधुमेह आदि जैसे विकारों और रोगों से बाधित होते हैं ।

Why Oscillate?

From birth to death an organism experiences a myriad of different stimuli, many of which are cyclic. Migration, mating, courtship behaviors, hunting, and sleep-wake cycles are all cyclic processes repeating in a regular manner i.e. a rhythmic manner. Ranging from minutes to days and even months, these biological rhythms help the organism cope with its environment's physical rhythms like the seasons, light-dark cycles, tidal movements etc.

> "The myriad of ways organisms keep time and how it affects them is a fascinating subject"

Circa Diem

Of particular interest are rhythms that repeat daily. Also called Circadian rhythms (from the Latin words "Circa"(about) & "Diem"(a day)). These rhythms influence numerous vital physiological, biochemical, and behavioral processes, from body temperature, feeding behavior, sleep-wake cycles to hormone secretion, and glucose homeostasis.

What makes a rhythm?

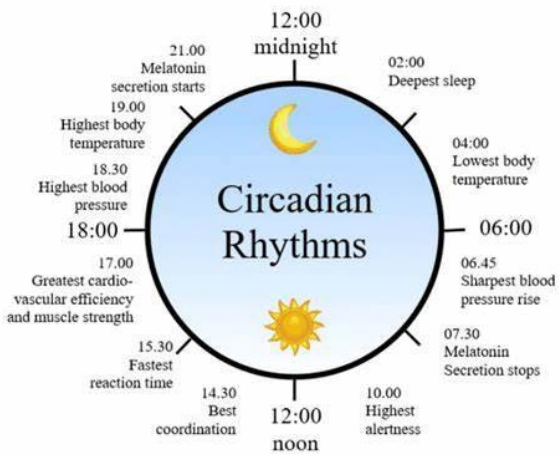
Circadian Rhythms present three main characteristics:-

1. **Circadian rhythms are free-running:** When shielded from all outside stimuli, and placed in a constant light environment, the organisms still show a circadian rhythm, referred to as free-running.

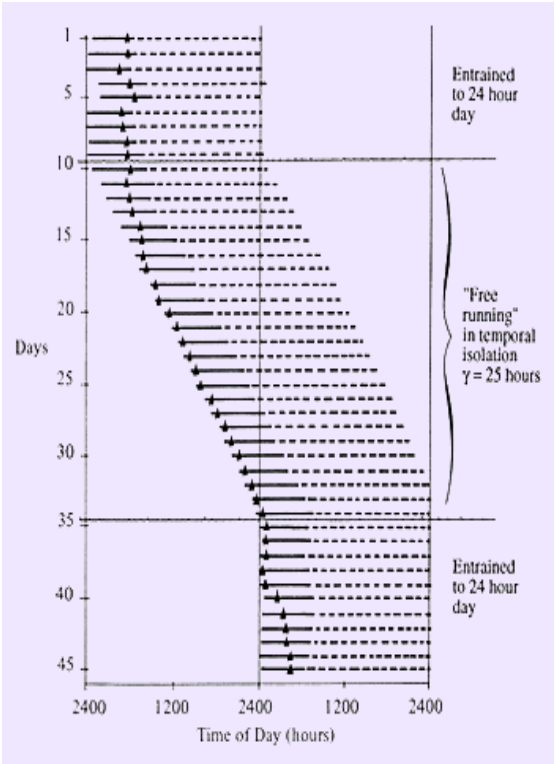
This in turn displays the endogenous nature of the rhythm, it continues running even in the absence of environmental rhythms, albeit at a frequency slightly different than 24 hours. Thus in a way these rhythms are a way for the organism to generate an estimate or measure of time independently of geophysical cycles(known as biological time).

2. Synchronization: In natural conditions, the rhythm is attuned to the light-dark cycles. This adaptive nature depends on the process of entrainment which refers to matching the period of the circadian rhythm to the period of the external cycle. This in turn establishes a constant time relation between a particular event of the circadian rhythm (such as awakening) and a specific event of the environmental cycle (such as dawn or dusk).

3. Temperature Compensation: The speed of the clock is temperature compensated so that changes in the temperature do not affect it.



Circadian Rhythm – the 24-hour cycle



Free-running observed upon temporal isolation

The Beatmaker

The circadian rhythms in vertebrates are controlled by the Supra-Chiasmatic Nuclei (SCN), located in the hypothalamus, SCN acts as a master clock synchronizing local clocks present in tissues throughout the body. The SCN itself is synchronized by inputs from specialized photosensitive cells in the retina.

At the molecular level, these oscillations are maintained by transcriptional and post-translational feedback loops involving a set of mostly conserved clock genes.

Surprisingly, circadian rhythms have also been reported in cyanobacteria. This might seem counterintuitive as prokaryotes generally have a lifetime smaller than a day(why bother keeping a timer for a cycle that is longer than your lifetime!?). However, prokaryotes are more like a mass of protoplasm that grows larger more so than separate organisms, so in that respect, while it won't make sense for the individual, the mass of the protoplasm does need to adapt and respond to cyclical changes daily.

Thus, we can see that these rhythms are an integral part of most organisms, now that we know how they work, we can talk about how we can use these to our advantage.

Hacking time

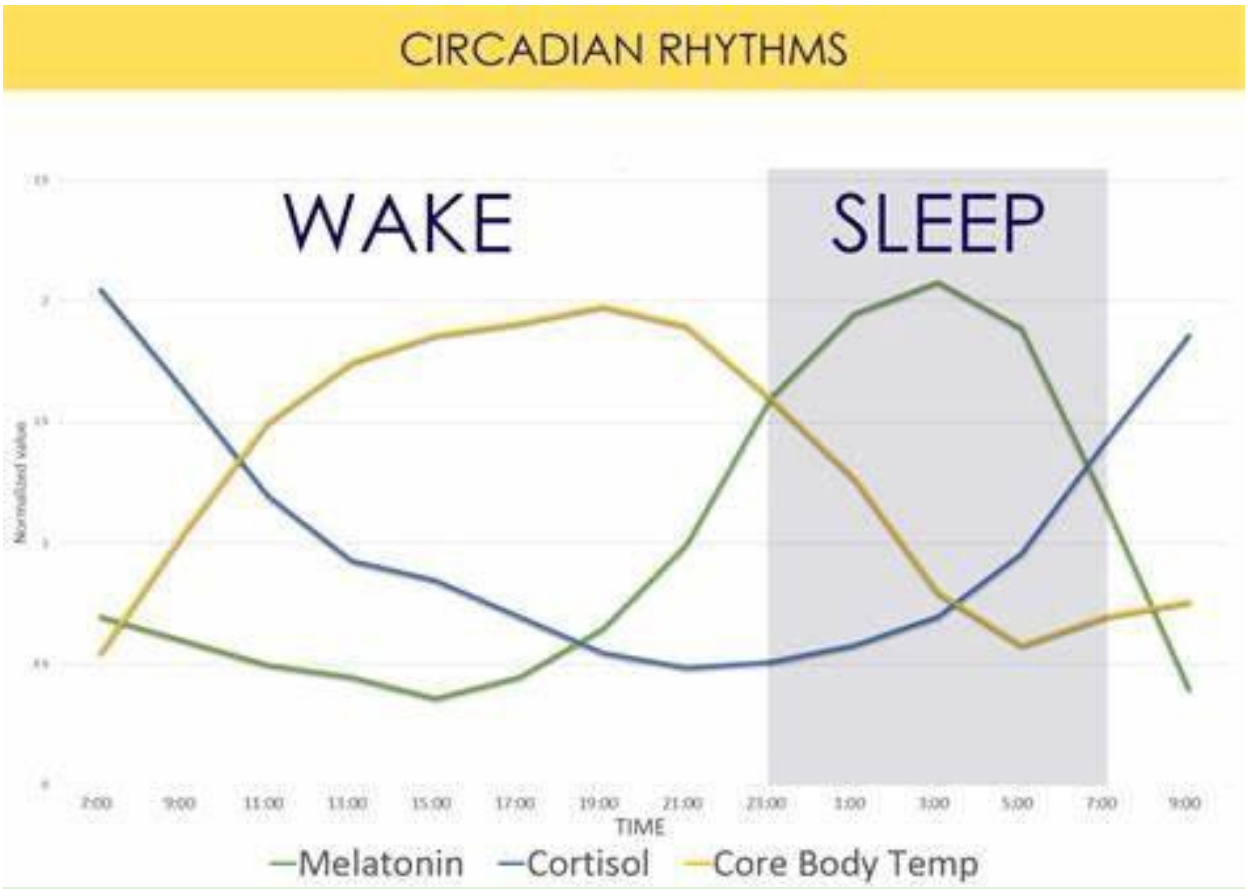
Circadian rhythms are ubiquitous when it comes to the control of bodily functions so it's only natural that disorders and diseases disrupt it. Scientists have also been looking at ways to manipulate the clock to their advantage.

- Many drug targets seem to show a circadian variation in their gene expression. Many studies show that the timing of drug application very likely affects the efficacy and toxicity of a drug. Further research into this could help improve the efficiency of these drugs. Conversely, the evaluation of rhythmic expression of "off-targets", as well as the drug clearance, could help reduce toxicity and side effects.

- Many cyclic genes were linked to the cardiovascular system, there is also evidence for cardiac disorders happening more frequently in the early morning hours. Thus the timing of the dosing has been shown to play a role in the efficacy of these drugs. An example being Simvastatin, whose efficacy is shown to be the greatest when taken before bedtime. Besides that, antihypertensive drugs such as nifedipine and angiotensin II receptor antagonists also elicit greater benefits in the evening.

- The circadian clock controls the "on" and "off" cycling of many functions that are important for cancer development. Disruption of the clock may cause these functions to get stuck on "on" or "off" state, creating the right conditions for tumors to develop and grow. Studies have shown that cancer cells often exhibit disruptions in the normal circadian clock of a cell. Moreover, targeting specific components of the clock in these cells might be a viable strategy for killing and controlling the malignant mass.

- The disruption of sleep-wake cycles has been linked with the development of metabolic disorders and diabetes. Animals



Circadian Rhythm in Humans

that are forced to eat during their resting period show an increase in body mass and a change in the expression of clock and metabolic genes. In humans, shift work that favors irregular eating times is associated with altered insulin sensitivity and higher body mass.

● Studies show that drug abuse profoundly affects the circadian clock via the central pacemaker(the SCN). People suffering from addiction show disrupted rhythms and these are even shown to cause a greater risk of substance abuse and relapse.

The study of circadian rhythms and their effects is a burgeoning field. The myriad of ways organisms keep time and how it affects them is a fascinating subject. We're only now beginning to realize the sheer impact that the circadian system has on our bodies, and further research will surely serve to cement that.

- Anurag Chittawar

Transposable Elements

Junk or Untapped Treasure??

मानवी जिनोम मध्ये फक्त 1.5 टक्के जिनोम हा प्रथिनान च्या स्वरुपात व्यक्त होतो. जास्तीत जास्त भाग अव्यक्त असतो. पुर्वी या ह्या अव्यक्त भागाला काही जैविक कार्य नाही असे समजले जात होते. त्याच्या असण्याने सजीवांना काहीही फरक पडत नाही असे पूर्वी लोक मानत होते. तर हा निरुपयोगी भाग नंतर मानवी जीवनासाठी कसा उपयोगी सिद्ध होतो हे आपण या लेखात बघणार आहोत.

Once the human genome was sequenced, scientists were in for a surprise as they found that only a tiny percentage-1.5%- of the genome coded for proteins or is transcribed. The bulk of eukaryotic genomes consists of DNA sequences that neither code for proteins nor are transcribed to produce RNAs. In the early decades, scientists considered these major portions of DNA as not having any biological function, their existence did not contribute to the fitness of the organism.

making up to 44% of the entire human genome (which is 75% of the "junk" DNA).

Jumping genes can introduce foreign DNA into a genome. They are also able to produce various genetic alternations upon insertion in a genome that is it can inactivate or alter the expressions of the genes. They can also help in the reorganization of a genome. Not only this, but jumping genes are also responsible for the deletion of mutated genomic DNA, and therefore, nowadays are widely being used

> "TEs can move around different positions of the genome of the organism either by copy-paste mechanism or by the cut-paste mechanism"

Junk?

However the comparison of the genomes of multiple eukaryotes has revealed the conserved nature of this DNA across species. For example, the genomes of mice, rat and humans contain almost 500 regions of identical non-coding DNA sequences. A level of conservation higher than is seen for protein-coding regions in these species. This in turn strongly suggests that "junk" DNA, might not be junk after all.

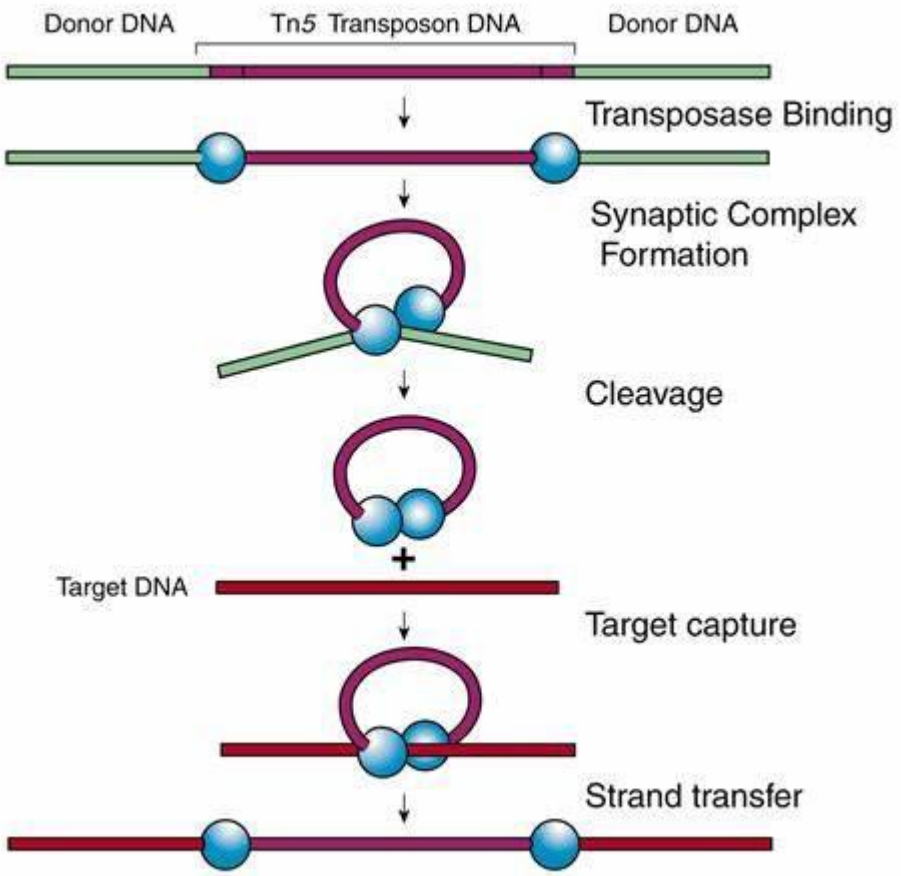
The Curious Case of Jumping Genes

In 1944, Barbara McClintock discovered transposable elements(TEs) while working on the maize plant. These TEs can move around different positions of the genome of the organism either by copy-paste mechanism or by the cut-paste mechanism. Hence these mobile segments of the DNA are popularly known as jumping genes. These segments are surprisingly prevalent in the field of biotechnology.

Mechanism of transposon transmission, these TEs move with a "cut-and-paste" mechanism with the help of the enzyme transposase. Another type of TE, called a retrotransposon move with the help of an RNA intermediate and a "copy-and-paste" mechanism. However, these jumping genes aren't all good. Many TEs are linked with multiple harmful mutations in the human genome ranging from hemophilia, SCID to a predisposition to cancer and Alzheimer's disease.

Other "Junk"

Repetitive DNA not related to TEs probably arises from mistakes during DNA replication accounting for about 14% of the human genome. About 33% of this consists



Mechanism of Cut-Paste Transposition

of duplications and repetitions of long stretches of DNA, with each unit ranging from 10,000 bp to 300,000 bp.

Tandem repetition

In contrast to these long sequences, the DNA also contains many copies of tandemly repeated short sequences known as simple sequence DNA. These Short tandem repeats or STRs are used for genetic analyses, these make up about 3% of the total genome. Much of this DNA is located at the telomeres and the centromere of the chromosome, suggesting a structural role for this DNA.

DNA as a structural molecule

Centromeric DNA might also help with the organization of chromatin inside the nucleus. Telomeric DNA a binds proteins that protect the chromosomal ends from degradation and from joining with other chromosomes. These regions of simple sequence DNA, are surprisingly difficult to sequence and determine the extent of and account for much of the uncertainty relating to the estimates of genome sizes.

- Aditi Chaudhari

Plant Meat, Anyone?

A Look into Plant-based Meat Alternatives

மனிதன் இறைச்சி உண்பதனால் அவனுடைய உடல் ஆரோக்கியம் கெடுவதுடன், சுற்று சூழலும் பாதிக்க படுகிறது. இதனால் விஞ்ஞானிகள் தாவரத்திலிருந்து இறைச்சி தயார் செய்யும் ஆராய்ச்சியில் ஈடுபட்டுள்ளனர். சிங்கப்பூர் பாலிடெக்னிக் விஞ்ஞானிகள் கோதுமை மற்றும் பச்சை பட்டாணி உபயோகித்து தாவர இறைச்சியை வெற்றிகரமாக தயார் செய்துள்ளனர். இது இத்துறையில் மேலும் பல ஆராய்ச்சிகளுக்கு வழி வகுக்கும்.

For all the curious science-loving, meat craving people out there here's something for you -a study was conducted by scientists from the school of Chemistry and Life Sciences, Singapore polytechnic, to develop a new and optimized plant-based meat alternative recipe.

Why plant meat?

The research comes at a time when consumers are moving towards adopting a vegetarian/flexitarian diet as a result of increasing awareness of the long-term health hazards resulting from consuming red meat — including increased risk of colorectal cancer and cardiovascular disease. Also, the increasing worldwide coverage of the ecological effects of rearing animals for food ,i.e. increased global warming, adverse impacts on biodiversity and land impacts like overgrazing have contributed to the rise of companies like Beyond Meat to worth more than billion dollars.

> "...adverse impacts on biodiversity and land impacts like overgrazing have contributed to the rise of companies like Beyond Meat..."

Methods

Coming back to the research, the focus was on the texture of the food item being like meat, as the main target audience for any plant-based meat product is meat lovers. The study used pea and wheat protein isolated in different ratios by weight in a nugget recipe. Pea protein and wheat protein were chosen due to their popularity among manufacturers of plant-based meat products - especially the latter due to their fibrous, viscous and elastic nature. Nuggets were made by combining protein and methylcellulose emulsions with other ingredients such as calcium chloride, potato starch, salt, baking powder in a food processor. The resulting dough was steamed, following which it was coated in flour and water and deep-fried. This nugget was then frozen at -200C for about 48 hours. This freezing forms an important part of the research, as it explains the method used to attempt to produce meat-like texture: the freeze structuring method.

Freeze structuring method

The freeze structuring method involves the use of ice crystals as a "cast" in order to organize proteinaceous fibers in a certain arrangement. The freezing of the nugget would lead to freezing of all the moisture in it, as a result limiting the fluidity of the protein emulsion inside. The ice crystals are removed, and what we get as a result is a new, porous structure with parallel fibers, with a certain resemblance to meat product architecture. Various properties of the proteins such as hydration, solubility, gelation etc. influence their arrangement.

The research further involved the study of color, physical properties such as hardness, chewiness, elasticity, viscosity, texture etc.

along with the microstructure of each nugget sample. Physical properties and microstructures were studied in commercially available chicken nuggets too, to facilitate comparison. These tests were carried out with the help of scientific equipment. However, a taste test was conducted to help analyze the mouthfeel the product gave in terms of taste and texture. All this was done after the newly structured nugget sample was baked in a pre-heated oven at 220 degrees Celsius for 15 minutes.

Plant-based meat tastes & feels exactly like meat

Results

The results obtained were quite intriguing, and for the most part, followed a certain trend, which made it easy to analyze:

1. Color: The samples overall had different shades of light brown, which could be attributed to the color of the protein isolates used. However, the shades vary, with the samples with more wheat protein being lighter than the ones with pea protein, due to variable time required to fry them.

2. Hardness and chewiness: Both hardness and chewiness decreased with the increase in the amount of pea protein. This is due to the difference in viscoelastic properties in all these samples. Analysis of each of these samples suggests that those with more pea protein are more elastic — because pea protein is intrinsically elastic (elasticity in physics is defined as the ability of the body to regain its original shape after removing a deforming force, and not merely the ability to flex — i.e. steel is more elastic than a rubber-band) in nature, hence the integrity of the pea heavy nugget is enhanced as a result. Cross-sections of nugget samples made with different ratios of pea and wheat (PP is pea protein and the number is the proportion of the same added. COM is the control nugget — a commercial chicken nugget). As far as chewiness is concerned, above analysis applies in a way that increased elasticity also accounts for a better protein gel strength, hence, intuitively speaking, it may need more time to chew a more elastic food item than a less elastic one. Thus, a nugget with a higher amount of pea is chewier than a nugget with a lower amount.

3. Microstructure: A cross-section of each nugget, along with the commercial chicken nugget was taken and analyzed under an electron microscope. All samples were found to be fibrous, dense entities, albeit to different degrees. It was found that with decreasing amounts of pea protein, the sections appeared less dense, more fibrous and porous. This could be because the presence of more wheat protein implies the formation of more bundles of thick fibers which facilitate cross-linking with neighboring proteins. The microstructure of the chicken nugget evidently resembled the 4:13 sample the most.

4. Taste: It was found that while there was little difference in terms of taste of each sample, as far as texture was concerned, it was the 4:13 pea to wheat protein sample that was most preferred, possibly because it gave a familiar mouthfeel, as opposed to the harder pea heavy nugget samples, or the softer pure wheat (0:17) nugget.

The research establishes that resemblance of texture to that of meat is imperative for the success of a plant-based meat alternative product.

- Ashwin Ananthanarayanan

Revolutionizing Waste Management

आज विश्व, विज्ञान का आश्रय ले बहुत तरक्की कर चुका है। इस विकास के साथ हमने पर्यावरण को भी अत्यधिक क्षति पहुंचाई है। प्रदूषण, विषैले रसायन तथा कचरा लगातार बढ़ रहे हैं तथा इनका बढ़ना गहन चिंता का विषय है। ऐसे में विज्ञान ही आगे बढ़कर समाधान भी लाया है। आज पुनर्योजी डीएनए तकनीक के माध्यम से ऐसे सूक्ष्म जीव बना लिए गए है, जो कचरे का पूर्ण पाचन कर उसे उपयुक्त पदार्थों में बदल सकें। साथ ही कृत्रिम जैविकी (सिंथेटिक बायोलॉजी) के माध्यम से प्लास्टिक को पचाने वाले एंजाइम का भी हाल ही में सफलतापूर्वक प्रयोग किया जा चुका है।

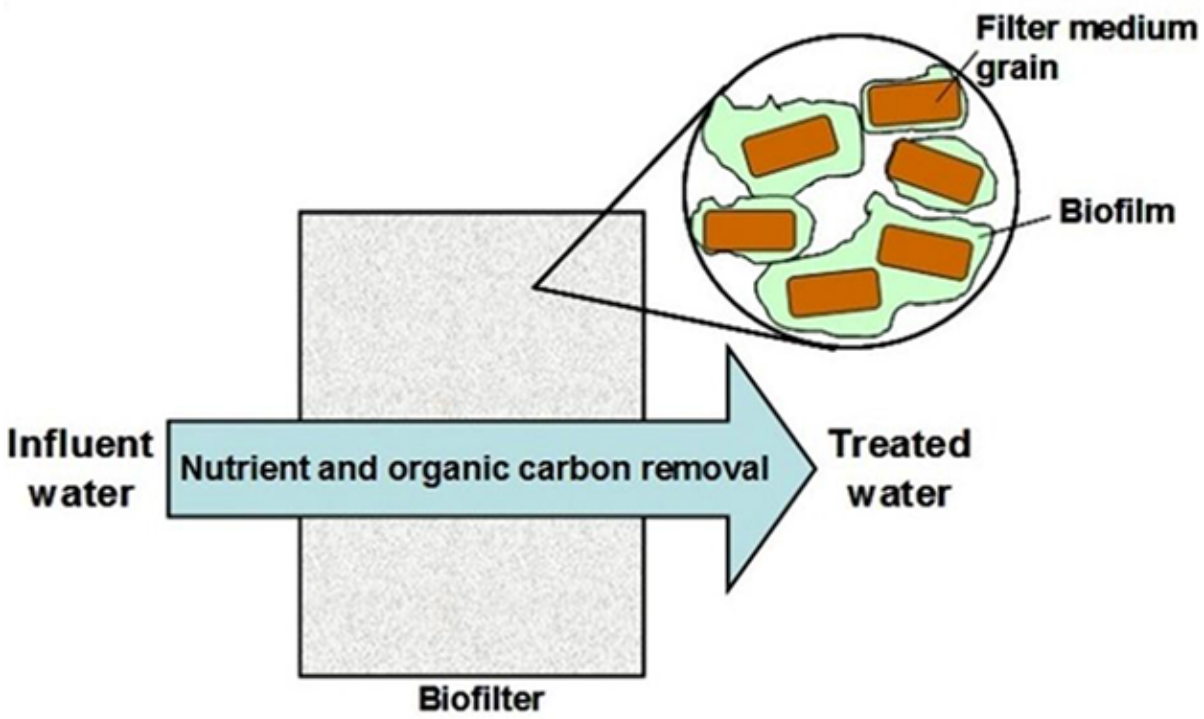
Today, we have rapidly progressed in the field of Synthetic biology. In modern times, its applications extend to agriculture, health, food processing, bioenergy and various industrial products. Slowly, we have also progressed to use synthetic biology in the field of environmental conservation too.

Industrial production has sky-rocketed in modern times to fulfil the needs of an increasing population which has also led to the release of toxic substances and waste products into the environment. Likewise, sewage, household waste, medical waste from hospitals, increasing vehicles on roads, extreme use of chemicals in farming, remains of dairy farms, harmful by-products from refineries, increasing use of plastic are contributing to manifold increase in pollution levels. Various countries from across the world have initiated treatment of these pollutants with the help of Synthetic Biology.

> “...to fulfil the needs of an increasing population which has also led to the release of toxic substances and waste products...”

Once the sewage is passed through primary treatments wherein sludge and other oils & grease are removed from it, the application of SynBio is seen at the secondary stages. To digest the carbonic substances *pseudomonas*, *micrococcus*, *nitrosomonas sardinia*, *staphylococcus* & *achromobacter* are used. In the airlift bio-reactors, zoogloea ramigera is used for producing bio-films & energy. Nitrosomonas and nitrobacter are used for digestion of ammonia, which converts them into nitrates. Then achromobacter (alcaligenes) and pseudomonas is used to convert these nitrates into nitrogen. Similarly, many protozoa, fungi and algae are placed on the periphery of these bio-films in bioreactors which digests phosphorus, nitrogen and other nutrients. Anaerobic bio-reactors in a similar fashion uses anaerobic bacteria viz. denitrificans, desulfovibrio, methanopterin, etc. which are used to digest fats, proteins and carbohydrates to produce methane and carbon dioxide.

The biofilm system could be a well-developed technology within which solid media are applied to suspended growth reactors to supply attachment surfaces for biofilms, thus on increasing the microorganism concentration further as rates of contaminant degradation require advantage of a variety of removal mechanisms, together with biodegradation, bioaccumulation, biosorption and biomineralization. The microorganism communities within the biofilm break down completely different nutrients, like chemical element and nitrogen-containing compounds, phosphorous materials further as treed pathogens from the effluent. Once pollutants are removed, treated water of a biofilter is either discharged to the atmosphere or used for agriculture and different recreational functions.



Wastewater purification using biofilms

Wastewater treatment with biofilm systems has many benefits, together with operational flexibility, low area necessities, reduced hydraulic retention time, resilience to changes within the atmosphere, increased biomass continuance, high active biomass concentration, increased ability to degrade recalcitrant compounds as well as a slower microorganism rate of growth, leading to lower sludge production.

Homologous DNA recombination technique has led to the development of such bacteria which can digest inorganic compounds too. This, in turn, has allowed us to remove the large quantities of pesticides which contain inorganic chemicals from the human body. Also, sea algae have been engineered such as to absorb D.D.T. and other harmful chemicals from the water. Recently, scientists were also able to develop a 'super enzyme' which degrades plastic six times faster than the earlier developed ones.

The super-enzyme was created by mixing two separate enzymes, which were found in a plastic-eating bug discovered at a Japanese waste site in 2016. Two years after the initial discovery, researchers revealed an engineered version of the first enzyme that was able to break down plastic in a few days. They determined that the structure of the enzyme, called PETase, can attack the hard, crystalline surface of plastic bottles and that one mutant version of it worked 20% faster. The latest study, published in Proceedings of the National Academy of Sciences, analyzed the second enzyme, which doubles the speed of the breakdown of the chemical groups liberated by the first enzyme. Now, they took this existing enzyme called PETase within Ideonella sakaiensis bacteria and combined it with a second enzyme, MHETase. These bacteria are already known to feed off of plastic, so it turns out to be a genius idea to amalgamate their enzymes with the second enzyme and increase the speed of activity further by three times, hence leading a six-times increase in plastic degradation.

Biotechnology is contributing immensely to the field of waste management and there is a hope that these steps would prove to be prominent for environment conservation soon.

- Saksham Jain

Next-Gen Vaccines

An Overview

लस हे एक जैविक मिश्रण आहे जे एखाद्या विशिष्ट संसर्गजन्य रोगास सक्रिय अधिग्रहित रोग प्रतिकारशक्ती प्रदान करते. आजकाल, लस बनवणे व त्याचा अभ्यास करणे फार महत्वाचे आणि गरजेचे झाले आहे. कृत्रिम जीवशास्त्र आणि रोगप्रतिकारशास्त्र चमत्कार कसे घडवून आणतात हे जाणून घेऊ इच्छिता? डीएनए लस, एमआरएनए लस आणि त्यांच्या यंत्रणेबद्दल जाणून घ्या.

As the situation surrounding the COVID-19 pandemic surmounts, attempts at finding a vaccine have intensified. The WHO lists about 180 COVID vaccines being developed around the world. Some use traditional methods, while others have their sights set on newer technologies that have never been tried before.

What is a vaccine?

Vaccines are substances that prepare the immune system to fight a pathogen. They mimic pathogenic molecules without infecting the body with the actual pathogen. The result is that the body has a "memory" of the infection without getting it.

Traditional vaccines do so by using by either using non-virulent varieties of the pathogen(known as "attenuated vaccines"), inactivated pathogens that have been destroyed (inactivated vaccines), using related microorganisms that do not cause the disease in humans("Jennerian" vaccines), inactivated toxic compounds released by a pathogen(toxoids) or by mimicking the surface polysaccharides of the pathogen(conjugate vaccine). However, these methods, while being very useful, also have a few drawbacks. To circumvent these, several innovative vaccines are in development.

DNA & RNA Vaccines

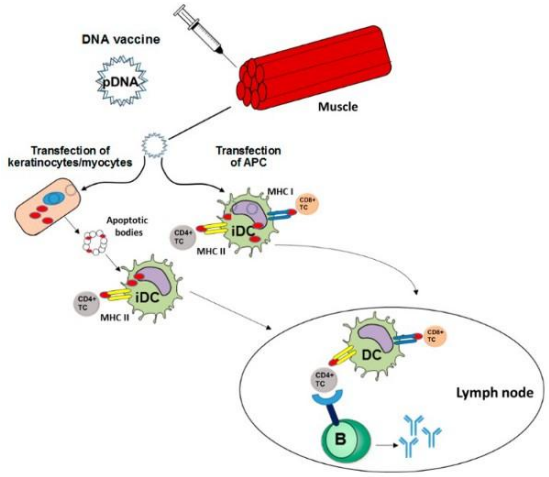
There are many types of biomolecules present in a living cell. Some of them are deoxyribonucleic acids(DNA), ribonucleic acids(RNA), proteins, carbohydrates, etc. In these molecules, DNA is more stable than other biomolecules in the cell. Due to its inertness, cells use DNA to store their genetic information. This property of DNA gives rise to the idea of using DNA as a material to make vaccines. These types of vaccines are called DNA vaccines.

DNA vaccines

A plasmid is a small, circular, and extrachromosomal DNA present mostly in

> "Vaccines mimic pathogenic molecules without infecting the body with the actual pathogen"

in bacteria. They may be found as single or multiple copies and may carry half a dozen to several hundred genes. While making plasmids synthetically, replacing some of the DNA by a sequence of base pairs that code for a protein present on the disease-causing agent's external surface, we produce a potential vaccine. The synthesis of plasmid DNA (pDNA) with a gene of interest follows its insertion in the person's body. There are two ways to insert pDNA in the human body. Intradermal delivery of vaccines means that the layer under the skin is the site of delivery of the pDNA vaccine. Gene guns facilitate intradermal delivery of pDNA vaccines. A Gene gun is a device used to deliver exogenous DNA, RNA, or protein to cells. On the other hand, intramuscular delivery of vaccines is the insertion of pDNA vaccines into a person's muscle cells. If this method is assisted by el-



DNA Vaccines – Mechanism of action; Credits: Hobernik et al. licensed under CC BY 4.0

electroporation, the DNA quickly passes through the membranes of the cell. Electroporation is a technique in which an electrical field is applied to cells to increase the cell membrane's permeability, allowing chemicals, drugs, or DNA to be introduced into the cell. This method improves the efficacy of the vaccine.

The plasmid enters the nucleus and integrates with the DNA of the cell. The central dogma of molecular biology occurs in the cells. Post translation, corresponding proteins are expressed on the cell membrane of the cells to trigger immune responses. The lymphocytes(one of the subtypes of a white blood cell in a vertebrate's immune system), especially T cells, recognize these structures and develop immunity against those foreign structures. The plasmid DNA vaccine is thus successful in creating immunity against the causative agent. DNA vaccination had emerged as an attractive immunotherapeutic approach due to its simplicity, stability, and safety.

Drawbacks of DNA vaccines

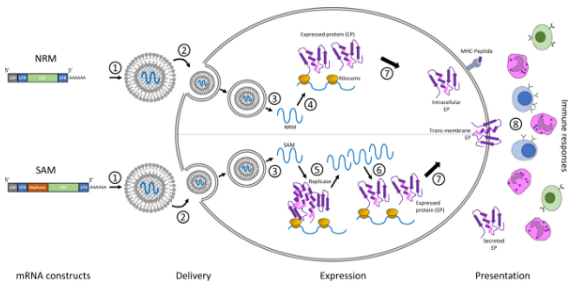
1. Suppressed immune response by the body
2. Immune Tolerance
3. Destruction of Naked DNA

Researchers are, thus, trying to find better options than DNA vaccines.

mRNA vaccines

Our cells have biomolecules called messenger ribonucleic acid(mRNA), present mainly in the cell's cytoplasm. According to the central dogma of molecular biology, DNA information is converted to mRNA and, ultimately, to proteins that perform various functions. In the DNA vaccines, DNA is used to store information about the protein expressed to build immunity against the disease-causing agent. mRNA vaccines skip the step of converting DNA to mRNA (i.e., translation) and directly store the required information into an mRNA molecule.

The main component of the mRNA vaccine is the mRNA molecule. The purpose of making the vaccine is to help cells make proteins that will stimulate the immune system to build immunity against disease. The mRNA molecule is made synthetically according to the sequence of amino acids (building blocks) required to make the antigen protein expressed by the cell on its membrane. Some vectors help in the delivery of this mRNA molecule. One of the methods used is the delivery of mRNA encapsulated in lipid nanoparticles. The lipids are a group of non-polar biomolecules. the lipid nanoparticles help deliver the mRNA in the cell's cytosol. The cytosol has many ribosomes. These make proteins(antigen) using the mRNA template. Expression of these antigens on the cell membrane stimulates the immune system to build immunity against the disease.



RNA Vaccines – Mechanism of action; Credits: Nicholas Jackson licensed under CC BY 4.0

Both DNA & RNA vaccines have their pros and cons. The choice of the vaccine solely depends on the purpose, cost, efficiency, safety, and many other factors.

- Manas Joshi

Biofuels & SynBio

The smarter alternative to conventional fuel

நாம் உபயோகிக்கும் எரிபொருள் பெரும்பாலும் புதுப்பிக்க இயலாதவை. மேலும் அவை புவியில் மாசு அதிகரிப்பதற்கும், வெப்ப நிலை அதிகரிப்பதற்கும், பருவ நிலை மாறுவதற்கும் வித்திடுகிறது. இத்தகைய விளைவை தவிர்க்க நிலையான எரிபொருள் உற்பத்தியில் ஆராய்ச்சி தீவிரமடைந்து உள்ளது.உயிரி எரிபொருள் ஆராய்ச்சியும் இம்முயற்சியில் முக்கியமான பங்கு வகுக்கிறது. செயற்கை உயிரியல் மூலம் உயிரி எரிபொருள் தயாரிப்பு மட்டுமல்ல, விவசாயம், சுகாதார மருத்துவம் மற்றும் பல துறைகளில் முன்னேற்றத்திற்கான வாய்ப்புகள் பெருகி வருகின்றன.

Most of the fuel we use today - whether it is kerosene to cook food or the petrol/diesel we use in our cars are sourced from petroleum products. Petroleum products are non-renewable -they are not usable in the long term- as they don't get replenished at the source upon consumption. Also, most fuels contribute greatly to pollution, global warming and climate change in the long term.

Such deleterious changes in the global living conditions coupled with an ever-increasing demand for fuel and the shortage of petroleum reserves calls for alternative sources of energy which are easily available, affordable and environment friendly. Thus, in response to this demand, a lot of research is being focused on the development of sustainable fuels which can meet these parameters. One such area where a lot of work is being put in is in the development of biofuels.

> "...fewer nitrates, sulphates and particulate matter released into the atmosphere and hence the pollution causing ability of biofuels is considerably lower."

A biofuel is any fuel obtained from the processing of material from plant, animal or microbial sources. It is certainly a cleaner alternative to petroleum-based fuels; as carbon dioxide emissions into the atmosphere considerably go down; potentially helping in reducing global warming. Also, these fuels burn more efficiently than traditional fuels, as a result of which there are fewer nitrates, sulphates and particulate matter released into the atmosphere and hence the pollution causing ability of these fuels is considerably lower.

Types of Biofuels

Biofuels are of three major types based on the source of extraction:

1. Cellulosic biofuels: Cellulose sources such as wood chips, crop residues, etc. These microbes use enzymes like cellulase to imbibe sugars into their system, which under the right conditions can form alcohol

2. Biomass-based diesel: Extracted from animal fat, leftover oil from restaurants or even algae with the larger cell membranes. This oil or fat is mixed with alcohol and processed to produce biodiesel.

3. Advanced biofuels: Generated from sources other than alcohol; for example, chemicals called isoprenoids (analogues of the simplest units of natural rubber)

Synthetic biology in biofuel production

Micro-organisms(mainly bacteria) play an important role in biofuel production. They help in processing raw materials, technically known as feedstock, into products of use. The raw material is typically a complex substance obtained from plant or animal matter, which is broken down into simpler substances by these microbes. The microbes take in these

simple substances; process (metabolise) them and under the right conditions, release the product substance (which is either alcohol or perhaps anything else). This product is now extracted, purified, processed and turned into usable biofuel. This is typically how biofuel is made.

Now, to produce a good output of product in terms of quality as well as quantity, we modify these organisms genetically by introducing new pathways to do so. The whole procedure by which this is carried out is known as Synthetic Biology. Synthetic Biology uses a "toolbox" of genetic and catalytic parts -which can fit together like a jigsaw puzzle to give us a product of our choice. Once a thorough study of what we want is carried out; a basic design for the desired pathway is created by genetic modification of an individual called a host (which is a bacterium most of the time), to form an artificially created individual called a clone. The product is tested for efficiency and if necessary, minor code modifications are carried out on the clone to ensure an optimized outcome as far as yield and productivity of the product are concerned. All this is to ensure that new methods of biofuel production are created, and existing ones are upgraded.

The research in the domain of biofuel production enhancement is happening through four approaches:

Traditional fermentation

The main objective of the traditional fermentation method is to enhance the production of ethanol, isopropanol and butanol, the three alcohols produced directly in nature. This is achieved by optimizing the metabolic flux in the host chassis using synthetic biology & metabolic engineering.

Non-fermentative higher alcohols

We produce alcohols which are otherwise not produced naturally in the host. But we can't just create a genetic pathway and insert it into them, as it may end up adversely affecting the health of the host. To prevent this, the metabolic reactions the host undergoes is taken advantage of. The product of interest from these reactions is partly utilised as precursors for producing new kinds of alcohols using enzymes whose genes have been introduced into the host from a new host.

Lipids

Here is something very different we want to do. Instead of using alcohol produced from these clones; we use the fat present on the cell membranes of the host- we extract it and combine it with alcohol instead of the other way around. Fat is produced in a cell from a substance called Acetyl-CoA. Sometimes, genes of enzymes involved in fat synthesis and that of enzymes involved in ethanol pathways are cloned into the same host. This leads to the production of a compound called Fatty acid Ethyl esters (FAEE), which are sources of biofuel.

Direct incorporation of Carbon Dioxide

Carbon dioxide-based technologies are used to produce precursors to alcohols, and even alcohols themselves. This method is used in photosynthetic algae and cyanobacteria.

Future scope

1. Broader study of metabolic processes will allow greater exploitation of microbes in biofuel production
2. Development of a larger "toolbox", to allow a larger array of hosts to be accommodated and used.

Algal Biodiesel

Overall, research on biofuel development with the help of synthetic biology is moving in the right direction.

- Ashwin Ananthanarayanan

The World of SynBio

A world of Synbio

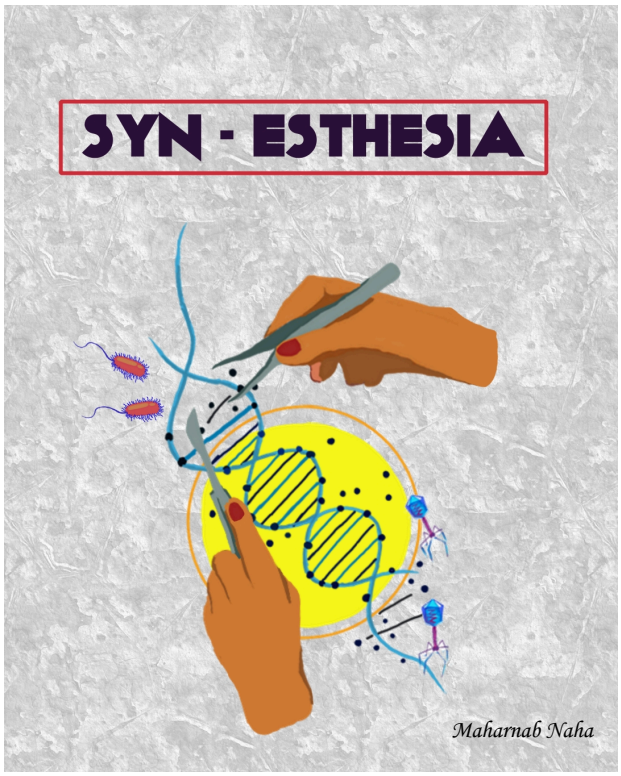
Synthetic biology (SynBio) is an interdisciplinary field within biology and engineering. It aims at redesigning genomes and engineering organisms to gain new abilities. The extent to which this field can be applied to solve current pressing issues is virtually endless. We, TU Delft's iGEM team of 2020, PHOCUS, would like to show you what is possible with SynBio, and give you a taste of how many dedicated people are striving to make an impact, like us.

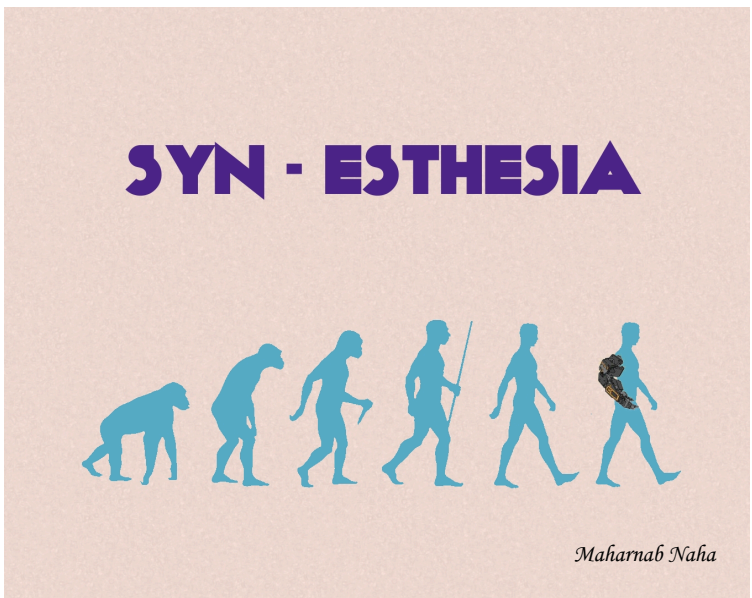
- **Team TU Delft 2020**

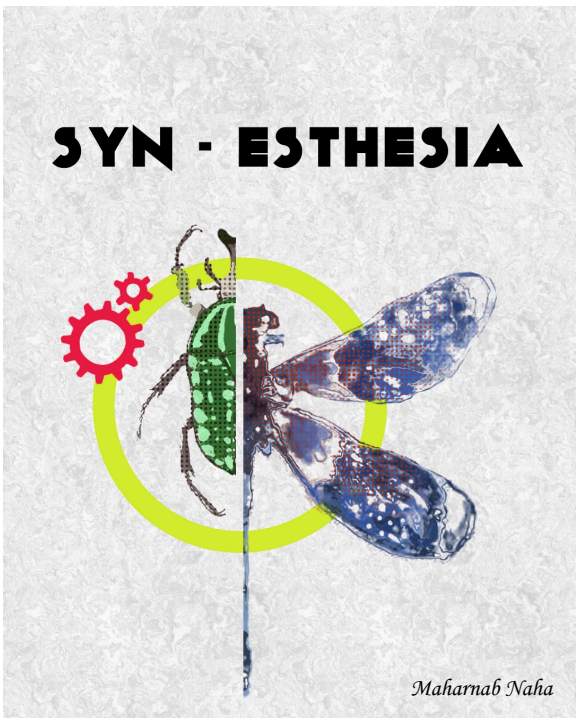
Click here to enter the world of SynBio!

Synesthesia

Unleash your Creativity with Synthetic Biology

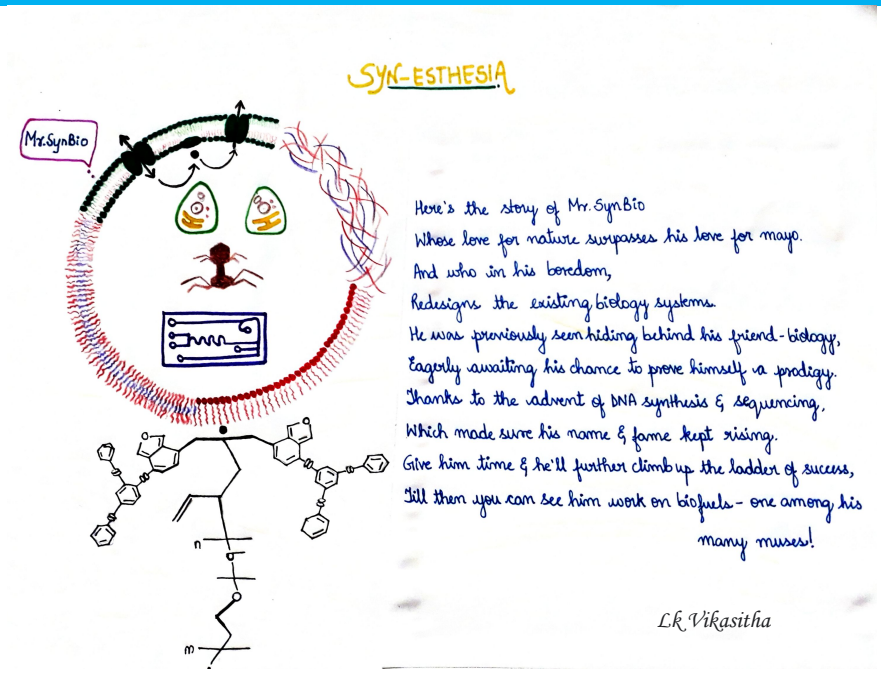






Synesthesia

Unleash your Creativity with Synthetic Biology



Zenization: the act of existing as a stranger

If you vigorously wake up a person from deep sleep
And look at the visible shock and confusion
They will at least have a purpose
Either to go back or rain on you
For followings a poet's instructions
But when I wake up
I fill with feuillemort
These memories of myself
being someone else
And a resonating question of
Who am I? Who am I?
Walking down lanes from my childhood
Yet not recognizing the person inside
Bearing nostalgia for a time
I have never known
This anhedonia
As if someone had stolen pieces of me
And replaced it with foreign dreams I don't listen to my own commands
Reaching out for the pills and knives
Knowing it's not something 'I' would do, If I'm not me then,
Who am I? Who am I?
From one relatable mess to another
Scrambled eggs is no longer a dish
The tingles of microinjections
Like a numb part waking after anaesthesia
Slowly remembering what it felt like to be alive
Soreness and aches you can't explain
But they exist
Open ends like hair with split ends
Extending arms reaching out to grab
Just something to hold onto
But emptiness has its ways
I'm trying to remember a person
But the person has always been me
Who am I? Who am I?
It's an empty kilig from a distant land
I wonder when I'll reach my klexos
Because I've done my questioning
And thought this through generations
But I just keep dividing and fading into brittle pieces
I may be my mother's success but not my own
Who am I? Who am I?

Meesha Katyal

White Cemeteries

Just writing the title gives me writer's block;
Don't know where to start, just like we don't know where to stop;
Critical biodiversity fuzzy, blurry and disappearing with the sound of the running clock.
Looking away, staring at the wall;
Like an ostrich with my head in sand, waiting for the right call;
Indentations all over the once immaculate shore haunt my peripheral,
What's lost, Nature still looks pretty ethereal,
I can't look directly in the eye; denial is so much more real.

My blank slate constantly looks for a scapegoat,
When everything looks so bleak and about to bloat;
Once exorbitantly vibrant and animate,
Was a mesh intertwining myriad worlds,
Now reduced to naked white flesh forgotten in swirls.

All vibrant colors and their hues manifested as monotonous whites,
Philanthropic coral reefs just remain in memories as laptop wallpaper sites.
Massive stretches of uncountable unparalleled creation,
The isohel, flora and fauna all melting as an unaccountable entity;
Don't make this esoteric we're all in this together,
We, the situation, its gravity and the impending harsh reality.

Looking at aesthetic coral images, I can't help but feel like I should see them at least once;
But all I see is mindless development and earth's smartest organism reduced to a natural dunce.
The ocean's dying and starved corals stand stark naked, their memories running dry;
I don't know how we messed up so much, but I do know now's not the time to cry.

Three major bleaching events already, don't want any more,
That's when I discovered synbio and turned the situation into a folklore.
Genetically modifying corals into heat resistant perpetuals, who knew that would be possible some day;
We've come so far with our selfish genes, sweeping consequentials under the carpet and leaving all ecosystems to fray;
Now's the time to look at the bay and sway every possible problem away.

The incredible power and precision of synbio really stuns me at times,
It's not just science, it's a tricky art with a lot of philistines.
With a single snip the history potentially changes,
Amnesiac vectors carrying memories of the future.
It's time to take some big steps now,
Careful to not leave any more footprints;
For the sands of time and unsullied nature haven't yet unfurled all their shades,
Let's not replace humble leaves with greedy loopholes and vapid green spades.

White cemeteries turned into vibrant kaleidoscopes once again,
At this moment, small namesakes just serve as euthanasia and inflict more pain.
With DNA ligase mending and sealing our broken connection,
RNA polymerase and replication factors playing God with perfection,
Natural concerns and valid trepidations sure do arise.
But what else are we left with to make up for the lost nick,
With the ecosystem domino falling apart with every passing tick;
CRISPR Cas-9 gives us some hope at least,
That's far more pragmatic now than to placate our own unleashed beast.

Amey Danole