



HELICASE 2022



Spring Edition

cover page

" **A** Science magazine with scientific cover page". This is usually what we usually hear and see. So for this edition we tried to do something different, add some artistic flair to it. The cover page with a flying bird might seem vague at first sight, but it tells much more.

The Nobel Prize in Physics this year was awarded for "groundbreaking contributions to our understanding of complex systems". We have tried to bring this out with the usage of random complex patterns in red used in the right wing.

On the other wing we have tried to showcase a fingerprint pattern in black and white. This is a way of illustrating the thought behind the Biology Nobel Prize, i.e. "discoveries of receptors for temperature and touch."

The Chemistry Nobel Prize was awarded for "'for the development of asymmetric organocatalysis." We have tried to showcase a degree of asymmetry with every aspect of the artwork, from the wavy lines to the background.

For illustrating the idea behind the Nobel Prize of Peace and Literature, the bird as a whole speaks volumes. It's a symbol of freedom of expression which is a necessity for lasting peace.

Lastly, the Nobel Prize in Economics was given for "empirical contributions to labour economics". To portray the idea behind this thought, we have used bamboo to show the unity and strength of the labour class.

The artwork is open to any kind of interpretations cause that's what art is. We have tried to interlink art with science and this is just a humble effort at it. Hope you all like it !!

- **Arkadeep Mandal**

credits

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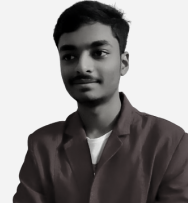
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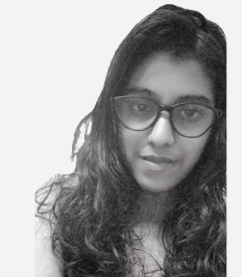
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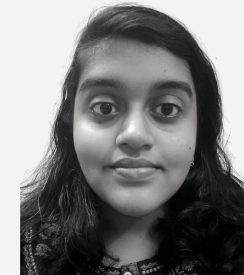
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Precisely 2.0

EXPECTATION: "EUREKA" REALITY: "Wow THAT'S WEIRD!"

- S. PADMAPRIYA

HYPOTHESIZE, VERIFY; REPEAT TILL YOU DIE.

-AISHWARYA JUNEJA

ENTROPY IS THE REASON I'M CHAOTIC.

- RISHABH KULKARNI

CURIOSITY KILLS CATS, BUT FUELS ME.

- APARAJITA SRINIVASAN

MY BRAIN GETS HIGH DOING RESEARCH.

- SAHIL JHADHAV

NEW EXPERIMENTS OUTCOME: RIP CURRENT UNDERSTANDING.

- S. PADMAPRIYA

SOLVING TOMORROW'S PROBLEMS THE DAY AFTER.

- VAISHNAVI REGHUNATH

BIGGEST CRIME, NOT MURDER BUT PLAGIARISM.

- ANIKA MITTAL

ASK "WHY?", FIND THE ANSWER, REPEAT!

- YASH GUPTA

WRITE ON MY GRAVE: $p < 0.05$

- DHAIRYA BHANDARI

MAIL IT TILL YOU MAKE IT.

- SAYAN NEOGI

”

“

ENTERS LAB. STARTS REVERSE ENGINEERING TRAUMA.

- SURABHI SINHA

FOOD FOR THOUGHT = FOOD FOR BODY

- VARAD LELE

WAIT. THE MONKEY IS STUDYING ME!!

- GAYATHRI S P

RESEARCH BECAUSE INSANITY'S ACCEPTED NOWHERE ELSE.

- ANIKA MITTAL

LIFE GIVES YOU QUESTIONS, PUBLISH JOURNALS.

- KAUSTUBH TANDON

WANNABE SCIENTIST? MORE LIKE "SCIENCE-TRYST".

- SRUDAN. P. MULE

MYSELF A WITCH, SCIENCE MY MAGIC.

- APOORVAA GOPAL

OVERWORKED? TAKE DAILY DOSE OF ASSIGNMENTS.

- AISHWARYA JUNEJA

READ 10 LINES FROM 50 PDFs

- SAYAN NEOGI

”

Editor's Note

Greetings from the Science Club!

We welcome you all to the latest edition of Helicase 2022. **Helicase is IISER Pune Science Club's biannual magazine**, which aims to provide a glimpse to all the club activities conducted throughout the year.

Putting together this magazine has been a fascinating journey for us, and we are grateful to our entire IISER family! We have received exciting articles and commentaries from undergraduate, graduate and postgraduate students, along with valuable insights from our faculty. We wish to thank all the volunteers who have worked relentlessly throughout the semester.

The time spent in this magazine's preparation was enriching and enlightening. The entire team of Helicase has passionately worked hard to present this magazine.

We are grateful to **Dr. Sudipta Sarkar, Dr. M. S. Santhanam, Dr. Kundan Sengupta** and **Dr. K. P. Mohanan (Thinq)**. Despite their busy schedules, they took out the time to contribute in the form of articles. Their belief in us has helped us shape the magazine in front of you.

Our heartfelt thanks to all the writers, editors, scientific advisors, and designers. Without their help, Helicase would not have been possible. We also wish to express our gratitude to our faculty coordinator **Dr. Amrita Hazra**, who guided us at every step. Along the same lines, our special thanks go to Arkadeep Mandal and Yatish Juneja who conceptualised the design and layout of Helicase. Finally we thank YOU, the reader, for taking the time to read this magazine. It wouldn't have been meaningful without you.

The journey through the conceptualisation, inception and execution of Helicase has been unique, riveting and memorable. We have tried our best to provide a new and exciting viewpoint of science, and we firmly believe that this will intrigue the nerd in you.

Thank you once again!

With best wishes,
Team Helicase



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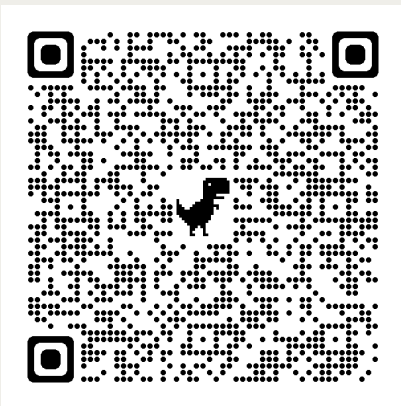
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NOBEL EVENINGS





Report by Ameya Kherde

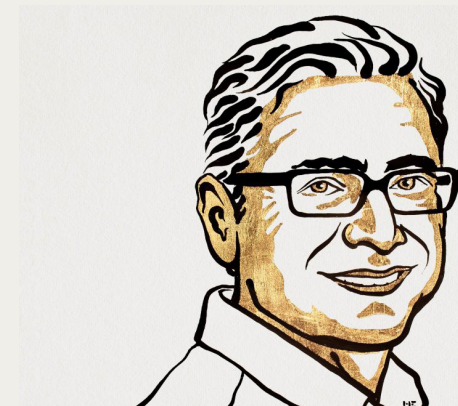
'Virtual Nobel Evenings 2021' commenced on 20th November 2021, where the first talk was presented by Dr. Nixon Abraham, a neuroscientist and assistant professor from the Department of Biology at IISER Pune. The topic was 'Nobel Prize in Physiology or Medicine 2021', with the joint recipients of the prize being Dr. David Julius and Dr. Ardem Patapoutian, for their discovery of receptors for temperature and touch.

Dr. Abraham initiated the talk by briefly touching upon the subject of senses. He explained how sensation and perception are the two steps to knowing a stimulus and demonstrated the same using the famous Tower of Pisa optical illusion. He presented two images of The Leaning Tower of Pisa, which when lined up side by side, appeared to be of different inclinations, but when superimposed they were revealed to be identical. This was followed by a brief explanation about the signal transduction of a noxious stimulus, and the roles of various regions of the brain in its perception. Having prepared the foundation, Dr. Abraham then explained to his audience the approach taken by the laureates while discovering the heat receptor. Dr. Julius and Dr. Ardem had set out with the aim of using natural toxins like capsaicin and tarantula venom to identify the mechanisms of pain and temperature perception. At this point, Dr. Abraham

took the audience on a necessary detour and spoke of some previous crucial developments in the field, namely, the hypothesis of capsaicin interacting with lipid membranes, and the discovery of the green fluorescent protein, both critical for the study.

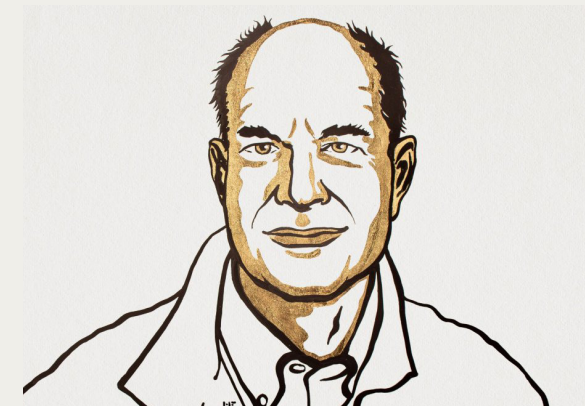
Returning to the topic at hand, he elaborated on the methods used for identification of the protein. First, mRNA pools were isolated from the dorsal root ganglion, which were already known to be sensitive to capsaicin; the extracted mRNA was introduced into non-neuronal cells, known to be unresponsive to capsaicin. Finally, by the use of a calcium sensitive dye, the responsible receptor protein was identified. Subsequently, the patch-clamp method was used to isolate the receptor along with a bit of cell membrane. This protein was then introduced into and expressed by *Xenopus* oocytes. Initially the protein was named VR1, but later it turned out to be similar to the TRP gene found in *Drosophila*, hence it was finally named TRPV1. TRPV1 was found to respond to heat and capsaicin. Soon, another variant of the TRP gene was found and named TRPM8, which was sensitive to cold temperatures and menthol. Dr. Abraham then added that the structure of both the proteins have been mapped, and that binding sites for various compounds, including capsaicin and spider venom, have been found.

PHYSIOLOGY



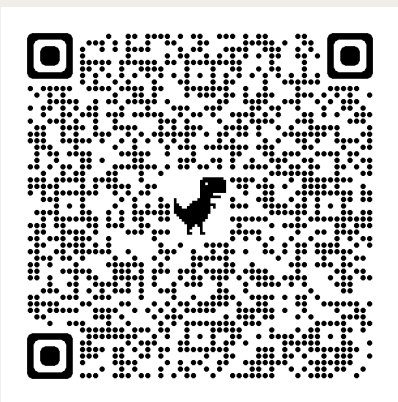
He then spoke of experiments done on mutant mice. The mice had undergone a loss of function mutation in the TRPM8 genes. The mutant mice were placed in a temperature gradient ranging from 30 degree celsius to 20 degree celsius. The same was done for wild type mice, which constituted the control group. It was observed that the wild type mice preferred to stay in the warmer end of the setup (30 degrees) while the mutant mice expressed no preference for any temperature. Dr. Abraham remarked on the significance of this finding, as the leap from molecular neuroscience to behavioral neuroscience is rarely bridged.

Dr. Abraham then moved on to the topic of touch reception. He briefly described the various types of touch and other physiological applications of touch receptivity. He explained how the approach used in this case was the opposite of the previous case; here, a mouse neuroblastoma cell line was taken, which was known to be sensitive to pressure. About 80 candidate proteins were selected and RNA interference (RNAi) was used to suppress one protein at a time, followed by testing for responsiveness to pressure. Eventually, they narrowed down to two proteins, that were named PIEZO1 and PIEZO2. These proteins, when expressed in cells known to be unresponsive to pressure, conferred



pressure receptivity to the cells. Dr. Abraham briefly mentioned the various potential applications of of this discovery, since these proteins had been found in a wide range of living organisms, including both plants and animals, where they are involved in various functions.

Dr. Abraham presented two clips of an experiment featuring mice. The mice were trained to differentiate between different airflow rates, which the mice did with the help of their noses. Next, the olfactory bulbs and neurons of the mice were removed. It was observed that the mice could no longer effectively differentiate between different airflow rates. This was later explained by the discovery of peizo2 in the mouse olfactory system. Dr. Abraham postulated that the discovery of function of these receptors might be to sense the breathing rate. He concluded his talk by remarking that these discoveries have opened up new possibilities in science and that scientists have their work cut out for them in the upcoming decades.



Report by Ahan Nag

The second talk on the first day of the Virtual Nobel Evenings, 2021 was delivered on Saturday, the 20th of November, 2021 by **Dr. Ramakrishna G. Bhat**, a professor in the Chemistry Department at IISER Pune. The 2021 Nobel Prize in Chemistry was awarded to Benjamin List and David W.C. MacMillan, for their pioneering discoveries in the field of asymmetric organocatalysis, which is one of Dr. Bhat's prime research interests.

Invoking Indian, Chinese and Ancient Greek philosophies, Dr. Bhat began his talk by reaffirming the central role that various molecules play in our everyday lives. From caffeine to oxytocin to various pharmaceuticals, he elaborated on the fact that almost all bioactive molecules have a chiral centre, that is, a carbon atom that is bonded to four different groups. Taking up the history of stereochemistry, he mentioned the seminal role of Jean-Baptiste Biot and Louis Pasteur in establishing the link between stereochemistry and optical activity, and how Pasteur's involvement with the French wine industry led to the realisation that optically active molecules possess "handedness", that is, they exist in two distinct forms that are mirror images of each other. He then gave many examples from the natural world to illustrate the importance of chirality, both on the macroscale and on

the molecular scale. R-limonene smells like oranges, whereas its 'mirror image', S-limonene, has the smell of lemons. However, chirality also has a sinister side, as evidenced in the thalidomide tragedy, where one enantiomer of a morning sickness drug prescribed to pregnant women caused severe birth defects in their children. Subsequent drug development has focused on producing enantiopure versions of drugs.

Dr. Bhat remarked on the difficulty of obtaining sufficient quantities of enantiopure chemicals from trees and other natural sources, as they contain very small quantities of these substances, thus setting the stage for the topic of his talk. He described organocatalysis as one of the 'three pillars' of asymmetric catalysis, along with enzymes (biocatalysis) and inorganic catalysis. The need for organocatalysis became evident when he discussed the problems with the other two approaches, with inorganic catalysts having toxic heavy metals and enzymes being extremely limited in their availability. He showed the overall mechanism for organocatalysis, wherein the catalyst 'shields' one side of the molecule and produces only one enantiomer in the reaction.

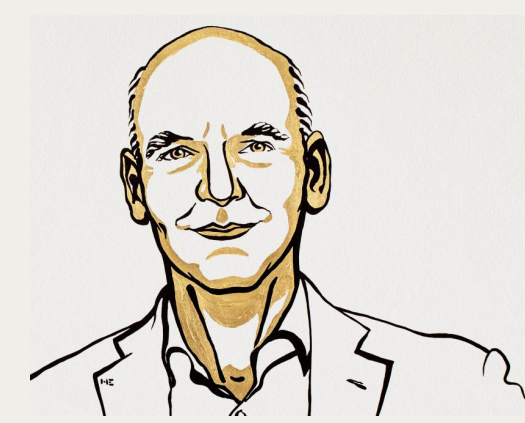
The first foray into asymmetric synthesis began in the 1970s with the Hajos-Parrish-Eder-Sauer-Wiechert reaction,

CHEMISTRY



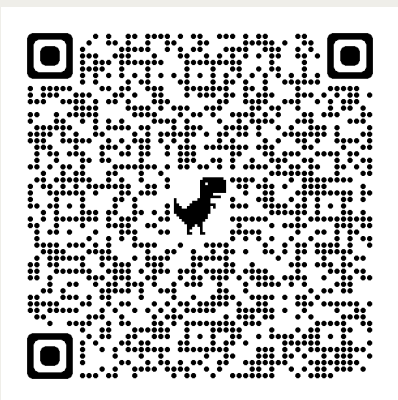
which, building on the work of Gilbert Stork, uses naturally occurring L-proline in making closed-ring compounds of only one chirality. Carlos F. Barbas, the late molecular biologist, had earlier noticed a link between this reaction and his own research on aldolase catalytic antibodies, and Benjamin List, then a postdoctoral student in his research group, took up studying that link. Dr. List's research culminated in the publication of a modified aldol reaction using proline, which produces one enantiomer in excess of the other. This trailblazing reaction was first published in the Journal of American Chemistry in 2000. Dr. Bhat explained the interesting mechanism behind this reaction, with the chiral proline first forming an enamine with one of the reactants and then engaging in a one-sided attack on the other reactant.

The second half of the prize was awarded to David MacMillan for his discovery of a highly enantioselective variation of the Diels-Alder reaction, which produces the endo product in excess over the exo product. Dr. Bhat explained in brief the properties of the organocatalyst that Dr. MacMillan developed for this reaction, touching on its characteristic "pocket-like" shape which causes the reactants to bind with it in a specific way, enabling asymmetric synthesis. He then went on to describe



the work of the many scientists who followed in the footsteps of List and MacMillan and expanded the field of organocatalysis to what it is now, an indispensable part of modern drug development in particular and organic synthesis in general. He elaborated on his own research in the field, and humbly stated that his students worked hard alongside him to bring their ideas to fruition.

Having quoted giants such as Confucius and Newton, Dr. Bhat concluded his talk by focusing on the road ahead for asymmetric organocatalysis. Several transition metals being used in inorganic catalysts are fast being depleted from the Earth's crust, and their use in the pharma and agro industries poses a serious toxicity risk to the environment. Organocatalysts, therefore, are a boon for sustainable chemistry, which has the potential to prevent the environmental degradation associated with most chemical industries. Both enantiomers of the target molecule are accessible by using the catalyst of appropriate chirality, which is not the case with most enzymes. At the fag-end of his talk, Dr. Bhat answered the audience members' questions and closed the session.



Report by Deep Shah

Dr. Deepak dhar, presented the first talk on 21st november 2021, as a part of nobel evenings talk. Dr. Dhar obtained his PhD from California Institute of Technology, and is an emeritus professor at the Indian institute of science education and research (IISER), Pune.

Dr. Dhar starts the talk by addressing the recipients of the Nobel Prize award of 2021, namely, Syukuro Manabe, Klaus Hasselmann and Giorgio Parisi. Dr. Dhar, elaborating on prof. Parisi, the spotlight of the talk, explains about his works. Prof. Parisi received his Nobel prize for his works on interplay of disorder and fluctuation in physical systems from atomic to planetary scales. Highlighting his famous works, dr. dhar mentions several of his famous works.

The dokshitzer - Gribov - Lipatov - Altarelli - Parisi equation and its play in quantum chromodynamics. The DGLAP equation describes the variation of observed parton [dressed quarks] densities in deep inelastic collisions of high energy particles.

He then progresses onto the topic of spin glasses. These spin glasses are a term given to an alloy of non magnetic metal (Copper) having small magnetic impurities (1% Manganese) when the temperature dependent susceptibility

graphs of these alloys are recorded, we observe an unusual peak at lower temperatures. normally this peak indicates a phase transition. However, no meaningful recording of magnetisation was obtained. The scientists thus concluded that the spins of electrons freeze in random directions, which is reminiscent of atomic freezing in glasses. Hence the phase is named spin glass.

Elaborating on the spin glasses, Dr. dhar introduced the term Broken Ergodicity. Ergodicity expresses the idea that a point moving in a system will explore all the possible parts of the system or space that the point moves in. Dr. dhar says that at low temperatures, the spin glass system has many local minimas of energy, thus meaning that the same system with identical conditions need not give the same averaged state which implies a replica symmetry breaking. Sir further explains this topic by the observation in the protein folding that is observed at high temperatures. On change in pH these proteins, which were in the extended form start contracting. However these folded states may not be unique meaning that this system can transform into more than one non-interconvertible state, thus breaking the ergodicity.

Sir then moves on to discussing the Kardar - Parisi - Zhang equation, or KPZ

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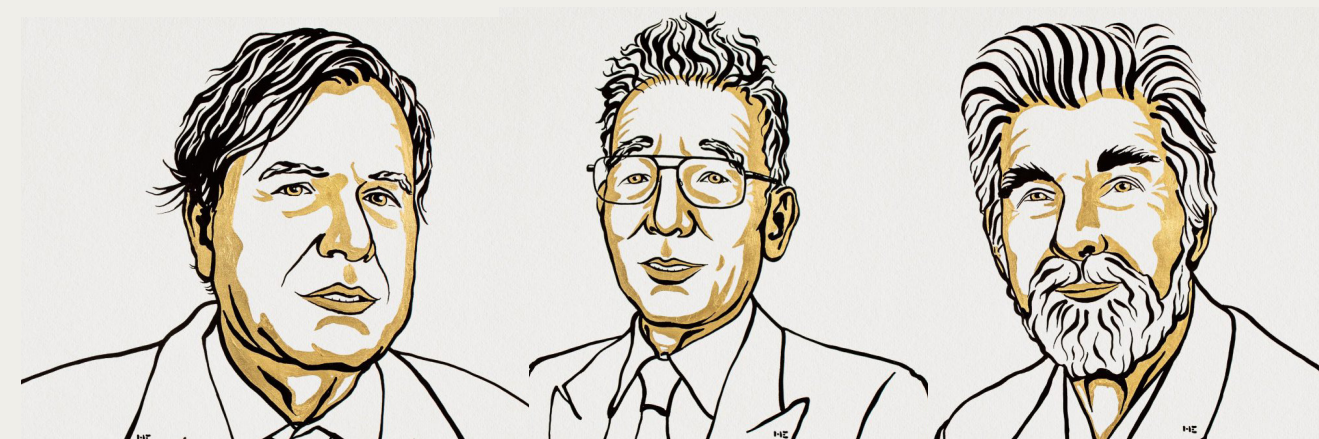
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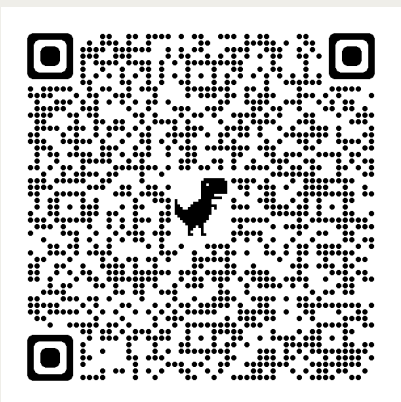


equation for short, which describes the fluctuation of height of a growing surface. like ice crystals on an ice layer. They showed through their equations that perturbations of wavelength L have decay time that varies as $L^{3/2}$. This was one of the first non trivial critical exponents determined exactly in a non-equilibrium setting. Sir then points our attention towards more implications and use of these equations to describe a variety of nonlinear evolution equations in one dimension, like in the case of traffic jams. sir concludes the topic by stating, "this is a paradigmatic equation of one-dimensional non-equilibrium physics."

Sir then shifts the audience's attention towards the work of prof. Parisi on climate variation. Earth's temperature undergoes a small periodic variation at a cycle of every 100,000 years, due to the presence of neighboring planets (as theorized before). However when the calculations are run in these conditions, the variation that comes out to be is not sufficient the variation observed. Parisi with benzi, vulpiani and stura proposed a theory in the 1980s and understood this phenomenon of stochastic resonance. Sir explains this topic saying that a complex linear system may exist in any one of the several possible 'metastable' states, and gives the example of 'Double well potential'.

In the double well potential the noise can push the point in either of the two possible wells and sometimes even over the walls of the well, to higher energy states. When we apply periodic noise to the system equal to the stochastic rate of transition between the states, we see a magnified response. Sir comments on this being an unusual case where noise amplifies the signal rather than dampening it. This phenomena is considered as stochastic resonance.

Sir concludes the talk by stating that the insights of prof. Parisi have led us to a better understanding of complex systems, which have been applied to the field of statistical physics extensively. outside the field of statistical physics, these have led to better explanations for protein folding, climate science and computer science.



Report by Jharnesh Verma, Avanthika Prasad and Asmi Gaikwad

The 2021 Nobel Prize in Physics was awarded “for ground-breaking contributions to our understanding of complex systems” with one half jointly to Syukuro Manabe and Klaus Hasselmann “for the physical modelling of Earth’s climate, quantifying variability and reliably predicting global warming” and the other half to Giorgio Parisi “for the discovery of the interplay of disorder and fluctuations in physical systems from atomic to planetary scales.”

On 21st November 2021, Dr. R. Krishnan gave a talk for the Nobel Evening series organised by the Science Club for the year 2021. Dr. R. Krishnan is an executive director and scientist at the Indian Institute of Tropical Meteorology, Pune. His research area includes climate modelling and analysis. He has been awarded with several honours and fellows including the MoES National award in 2021.

The talk mainly focused on the contribution of Syukuro Manabe and Klaus Hasselmann for the physical modelling of earth’s climate and quantifying variability and reliably predicting global warming. Dr Krishnan began the talk by stating the reason for awarding the prize, which was “for ground-breaking contributions to our understanding of complex systems”, and then elaborated on the need of modelling of physical

systems. Subsequently, he continued his discussion about Hasselmann and Manabe’s contribution to the physical modelling of Earth’s climate. Prof. Manabe developed the Radiative-Convective Model which was one of the most important contributions in climate sciences. Moreover, Prof. Manabe was the first researcher to explore the interaction between radiation balance and the vertical transport of air masses due to convection, also taking into account the heat contributed by the water cycle. Dr Krishnan described the complex dependence of climate on various physical factors like solar radiation, long wave radiation, greenhouse gases concentration, convection, etc. He explained that Hasselmann developed a stochastic climate model which separates signals from chaotic noises in a complex climate system. This model along with others provided the basis for developing detection attribution techniques of human induced climate change. As elucidated by Dr Krishnan, the recent changes in physical attributes such as temperature, etc. can only be described if we also consider the effects of anthropogenic drivers along with natural sources.

Dr Krishnan expressed his respect for Prof. Manabe by calling him one of the most outstanding climate modelist in the world. Further, he talked about Manabe’s

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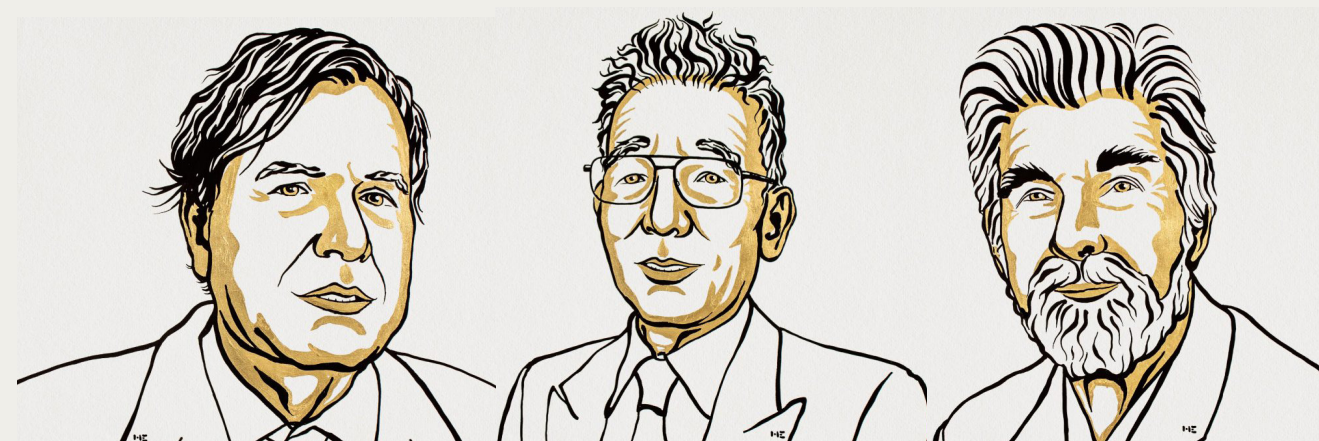
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research work and his wide range of landmark contributions in climate studies which were mainly about the modelling of different systems (atmosphere, ocean, etc.) and the way they change with factors like CO₂, etc. Elucidation of atmospheric radiative-convective equilibrium with positive feedback effect of water vapour, development of 3D models of atmosphere, quantifying the effect of increasing atmospheric CO₂ on earth’s climate, simulation for the first 3D response of temperature and hydrological cycle, first simulations of the climate by a coupled ocean-atmosphere model, etc. are some of those contributions. Dr Krishnan stated that several models built by Prof Manabe were first of their kind. He also shared the Nobel Prize winner’s approach towards climate science which was emphasising on understanding climatic phenomenon and physical processes of variability and change through simplification and reasoning. According to Krishnan, Prof. Manabe is a great inspiration who inspired the generation of scientists.

Moving ahead, Dr Krishnan gave an introduction to Numerical Weather Prediction (NWP). Early approaches by Vilhem Bjerknes and L F Richardson in the early 20th century were not very successful. He said that several obstacles had to be overcome to get a working model for NWP. In 1950, Jule Charney,

John von Neumann and Fjortoft, provided the first numerical atmospheric model through quasi-geostrophic approximation and hydrostatic balance. The first general circulation model of atmosphere was developed in 1956 by Philip N.A. which marked the starting of general circulation models. Lorenz E.N. in 1963 came up with a simple 3D model which showed two regimes with chaotic transfer between them. Lorenz argued that there is an upper limit to weather prediction.

Dr Krishnan explained that it was a dilemma of predicting climate, if one cannot predict weather beyond a certain point. This problem could be solved by Syukuro Manabe and Klaus Hasselmann through simple deterministic models along with computing power.

A brief introduction to the science of climate change was given by the speaker. From Joseph Fourier, John Tyndall to Svante Arrhenius, scientists in the 19th century contributed to climate science. Charles Keeling started measuring the atmospheric composition of gases around 1957. In 1964, Manabe and Strickler made Radiative Convective models to compute the states of thermal equilibrium. In 1967, Manabe and Wetherald examined thermal equilibrium of the atmosphere with a given distribution of relative humidity. This paper modeled the links between

temperature, altitude, and CO2 levels with a given relative humidity distribution. These models concluded that the CO2 levels lead to a higher temperature in the lower troposphere while the upper atmosphere gets colder. Prof. Manabe, thus confirmed that the variation in the atmosphere's temperature is due to increased carbon dioxide levels.

The results show that it takes twice as long to reach a state of radiative-convective equilibrium for the atmosphere with a given distribution of relative humidity than for the atmosphere with a given distribution of absolute humidity. According to their estimate, doubling CO2 levels would increase the atmosphere's temperature by 2 degree Celcius, given a fixed relative humidity. Prof. Krishnan mentioned it was a clever strategy from Prof. Manabe's side to set the relative humidity because the absolute humidity depends on air volume. In contrast, relative humidity only depends on the temperature, and it will not change with seasons.

The next paper discussed by Dr. Krishnan was - "Thermal Equilibrium with a Convective Adjustment" by Syukuro Manabe and Robert F. Strickle, which used convective adjustment to compute the mixing ratio of water vapor to calculate the temperature change due to radiation. To study this model, first calculations were performed for purely radiative equilibrium to study the thermal equilibrium with convective adjustment. They made a radiative-convective model for understanding how the vertical distribution of temperature is achieved in the atmosphere. Pure radiative equilibrium contains a shallow tropopause because the rate of cooling in the troposphere is faster. In comparison, the rate of cooling of the troposphere is slower for the thermal equilibrium with convective adjustment.

Additionally, Dr. Krishnan stated that this

paper showed that the surface temperature for pure radiative equilibrium is higher than thermal equilibrium with convective adjustment. This statement indicates the high surface temperature in arid/semi-arid regions where the radiation is high and the tropopause is shallower. In contrast, the surface temperature is cooler, and convection cycles occur in the deeper troposphere in monsoon regions and places.

Prof Manabe and Prof. Hasselmann also studied the General circulation model in 1975. With the help of a three dimensional model they could cover the Atlantic ocean, North and South America (both land as well as sea). They studied the transportation of heat in the atmosphere, and not just the vertical convection but also the lateral transport of heat in both the atmosphere and the oceanic regions. In this paper they also looked at the effect of the hydrological cycle where it was said that if the carbon dioxide concentration was doubled, the intensity of the hydrological cycle would become stronger. This confirms that precipitation will intensify with climate change. Hence the subtropical deserts will get drier. While the concept that the intensity of the hydrological cycle will intensify was already pointed out in 1975, Professor Manabe pioneered the development of coupled climate models which involved not only the atmosphere but also oceans, land and cryosphere. This was with Kirk Bryant Stouffer on how the exchanges of heat fluxes, momentum, and freshwater between atmosphere and ocean took place.

According to Prof. Hasselmann, weather is a chaotic system. This applies to extreme events like heat, storm or heavy rains. The German researcher analysed this chaos decades ago and contributed significantly to understanding the climate catastrophe. According to him, if the mean climate is altered, only then the extremes (like heat,

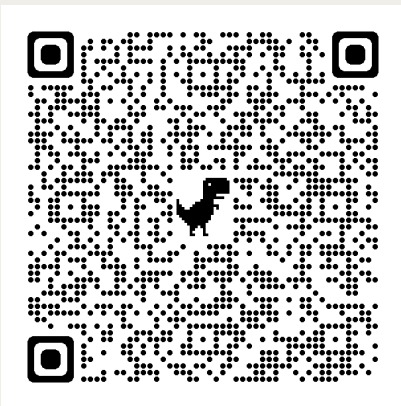
excess rainfall, etc) can be controlled. Warned as early as 1988, in 30-100 years depending upon the consumption rate of fossil fuels, we will be facing very significant climate change such that the climate zones will shift and there will be changes in the precipitation patterns and no longer we will be able to talk about random results.

The next paper was- "How slow climate change is followed by an integral response to continuous random excitation by short period weather disturbances", by Prof. Hasselmann and Telus. Here they'd described how slow changing climate patterns could create integrated random disturbances in the climate change in the near future.

Proceeding towards the final part of his talk, Prof. Krishan went on to address the detection and attribution of recent climate change. This paper states that human activities have not only added greenhouse gases to the atmosphere but also a significant amount of aerosols due to vehicular pollution, industrial emission, etc. Detection of the harmful levels of these is possible via measuring temperature, gas emission, etc. If these changes are not timely controlled, then average warming of the planet beyond 1.5 degree Celcius would be inevitable. Many other models predict that from 2080-2100, the average rise in temperature would be around 2.7 degree Celcius.

Similar predictions were also made for the first time by IATM, India where they said that the average temperature rise range would be around 2.3 degree Celcius which approximately matches with the predictions in Hasselmann's paper.

With this, the talk was finally concluded.



Report by Mugdha Ashirwad Thatte

On 24th November 2021 (please review the date), Dr. Pooja Sancheti delivered a talk on the 'Nobel Prize in Literature' for the Nobel Evening talk series, organized by the Science Club of IISER Pune. The Nobel prize in Literature (2021) was awarded to Abdulrazak Gurnah for his 'uncompromising and compassionate penetration of the effect of colonialism and the fate of the refugees in the gulf between cultures and continents'.

The talk commenced by providing a general overview of how the Nobel Prize in literature was awarded. The prize is typically awarded by considering the amalgamation of the author's work throughout their life instead of awarding it for a single outstanding piece of work.

Dr. Pooja Sancheti then proceeded to talk about this year's Nobel prize winner Abdul Razak Gurnah and his tumultuous early life. Gurnah moved from his home in Zanzibar to England at the age of 18 due to political unrest in Zanzibar at that time. His writing stems from the feelings of homesickness and the underlying sense of displacement that accompanied it. Dr. Sancheti added that Gurnah uses his writing to highlight the experiences of being a refugee, the trauma that emanates from being eclipsed by war and colonialism, the race relations in Europe, and the voices of the unheard

who would not make it to the archives. In an excerpt from one of his essays, he says, "I began to write casually, in some anguish, without any sense of plan but pressed by the desire to say more.... When I began to write, it was that lost life I wrote about, the lost place and what I remembered of it," referring to the life he left behind in Zanzibar.

Following this, Dr. Sancheti then dove into the literary works of Abdulrazak Gurnah. She especially emphasized that Gurnah is a notable academic and novelist and a short story writer, which is relatively uncommon for someone in this field. He is an emeritus professor at the University of Kent and has published numerous critics, essays, and articles on postcolonial literature. His writings talk about what it means to be a post-imperial writer and how European audiences receive it.

Apart from academic essays, Gurnah's writing also spans short stories and novels mainly situated on the East Coast of Africa and temporally in the colonial period. Dr. Sancheti also mentioned that, surprisingly, his novels had not been read much outside of academic circles despite not being esoteric. However, even though his novels have not been wildly popular, they are very gripping and easy to understand even to ordinary people outside of literary circles. She then added

LITERATURE



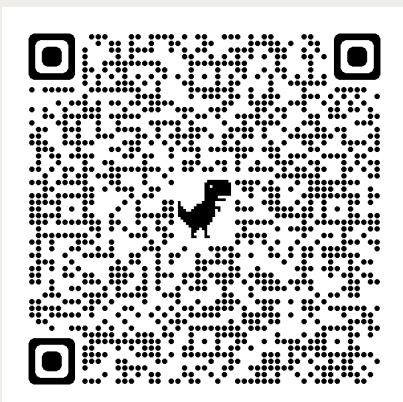
that Gurnah could be considered an anomaly when it comes to Nobel prize winners since he has only ten published novels, which is a relatively low number compared to other Nobel laureates. His novels have been nominated and shortlisted for various awards. Maaza Mengiste, an Ethiopian-American writer, wrote about Gurnah, saying, "In book after book, he (Gurnah) guides us through the seismic history moments and devastating societal ruptures while gently outlining what it is that kept those families, friendships, and loving spaces intact, if not fully whole."

Dr. Sancheti further talked about the history of African writers and the Nobel prize in literature. She pointed out that Gurnah is the first Black writer to win the Nobel prize after Toni Morrison in 1993 and the first African writer since 2007. He is one of only eight African writers to receive the Nobel prize. She added that 2021 was a good year for writers from African countries and the African diaspora and mentioned various award-winning African writers and their works.

On a concluding note, she urged the audience to read two of his works- 'The writing place' and the short story named 'the wood of the moon.'

The talk then proceeded to the discussion part, where one of the

audience members brought up that Europeans giving the Nobel prize must have some implications on the nomination of writers from the oppressed communities and progressed to ask if the process is authentic and without a bias. Dr. Sancheti replied that most postcolonial writers are conscious of this possible bias and the stances of all writers concerning this differ individually. As far as Gurnah is concerned, she would categorise him among the writers who have not 'sold their souls. Many post-colonial writers have been subjected to accusations of pandering towards the West. In contrast, some have clearly stated that awards like the Oscars or the Nobel Prize are a thing of the West and do not necessarily need an endorsement from the West.



Report by Rishabh Kulkarni

The first talk of Day 3 of the Nobel Talk Series was given by Dr Mrinalini Jha, on the awardees of the Sveriges Riksbank Prize in Economic Sciences 2021, also known as the Nobel Prize in Economics. This award was jointly awarded to **David Card** for his empirical contributions to labour economics and **Joshua Angrist** and **Guido Imbens** for their methodological contributions to the analysis of causal relationships.

Dr Jha began her talk by mentioning the importance of the **Credibility Revolution** and how critical it is for understanding the economy we live in. This talk was divided into two parts. The first part covered the evolution of **impact evaluation** and the methods developed for its measurement so far. The second part highlighted the specific applications of these methods to the labour market and economics. The discussion ended with Dr Jha illustrating general examples specific to Indian economics and how impact evaluation methods have given a better idea about the Indian economy.

The very first aspect Dr Jha talked about was 'the difference between 'Correlation and Causation'. She explained this by considering two events, X and Y happening simultaneously, where X was the rise in the number of young drug addicts and Y was the rise in the

number of thieves. Dr Jha stated that even though X and Y were correlated, X did not need to be causing Y. We could consider a third event where there was an increase in unemployment, which could cause events X and Y together. With this arises the following question—how to credibly determine the causality of an event with proper evidence? This happens to be an extraordinarily tedious and tricky task for which different methods have been developed.

Next, Dr Jha gave examples of the methods like Ordinary Least Squares (OLS), Difference-in-differences(D-i-D) and the Randomized Controlled Test (RCT). Estimates from OLS have been biased till now. Reasons for this include endogeneity problems, meaning that when one estimates that event X causes Y, the actual causes could be the opposite or omitted variables. For instance, in the example given earlier, the factor 'unemployment' was not considered a possible cause. The D-i-D method, on the other hand, is a quasi-experimental approach to this problem. Research work has been and is still continuously carried out to get more confidence in the estimates for causality. However, the gold standard of measuring causality is the RCT method, for which Kremer, Duflo and Banerjee won the Nobel Prize in Economics in 2019.

ECONOMICS



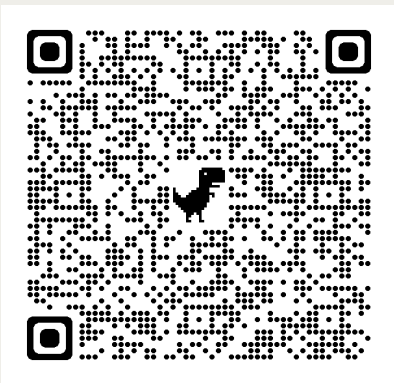
Execution of RCT relies on the computerised generation of two randomised groups of people where one group is administered a treatment. Post-treatment differences in outcomes of the experiments for the two groups are then attributed to the treatment. Dr Jha, however, specified that RCTs had been openly condemned since treatments can be tremendously expensive and not all people in the group can afford them. Moreover, they can often be unethical.

Hence, to overcome these exceptions, the concept of **Natural Experiments** was adopted. Unlike RCTs which measure the impact of the intervention designed for that purpose, Natural Experiments are generated via policy, institutional or environmental factors. These factors are used to estimate economic parameters. The objective was to get as close to the gold standards of measuring causality using RCTs as an inspiration. After introducing the term, Dr Jha elaborated on the case studies of Card (1990), Card and Krueger (1994) and Angrist (1990), who used Natural experiments to get insights about the labour markets. The element common to all these experiments was that the predictions or estimates made using simplistic models contradicted the real-life outcomes.

In the last part of the talk, Dr Jha spoke

about some examples pertinent to the Indian economy. She briefly explained the two papers by Bhavnani (2009) and Cassan (2011). The Bhavnani paper compared the probabilities of women winning an election with and without reserved constituencies. In contrast, the Cassan paper disproved that only providing reservations to marginalised communities by including them under Scheduled Castes was not enough to improve the economic and schooling conditions of those groups of people.

Dr Jha ended the talk with the description of a recent study by Asher et al. (2021). This study showed that investing in rural infrastructure development programmes would not decrease the level of poverty in rural areas. In conclusion, Dr Jha emphasised that Natural Experiments allow us to draw credible inferences about how our economy functions and make appropriate decisions for a better future.



Report by Akilan R.

With the final topic of the Nobel Evening Series, Nobel Peace Prize, the exciting series came to a close. The Nobel Peace Prize was awarded to Maria Ressa and Dmitry Muratov for their efforts to safeguard freedom of expression, which is a precondition for democracy and lasting peace

Dr Namrata Singh, a renowned professor from the Department of Political Science at Miranda House, University of Delhi, spoke on this year's Nobel Prize. In her opening remarks, she described the significance of the Nobel Prize and briefly described its history in the 1900s and explained the role Sir Alfred Nobel's vision of global peace in the world was embodied in this Nobel Prize. Regarding the Nobel Prize, his will reads - "the interest on which shall be annually distributed in the form of prizes to those who, during the preceding year, shall have conferred the greatest benefit on mankind"....." and one part to the person who shall have done the most or the best work for fraternity between nations and the abolition or reduction of standing armies and the formation and spreading of peace congresses"

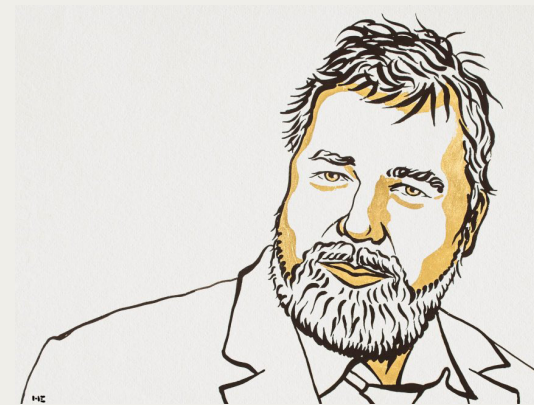
In addition, she touched upon the work of Baroness Von Sutner, the first woman to win the Nobel Prize. She explained the significance of this year's Nobel Prize with great optimism.

According to her, in this age of digitalization, where corruption is on the rise, power and information are held by a few. She emphasized that the Nobel Peace Prize winners of 2021 were a testament to the importance of freedom of speech and expression as a crucial aspect of democracy.

First, she described Maria Ressa's courageous fight for freedom of expression. During her opening remarks, she described her early life and career - Maria Ressa was born in Manila and studied at Princeton. She went on to become a CNN investigative reporter, and then became a faculty member of her Alma Mater. She then explained that Maria became the founder of Rappler - an independent news website that created "ripples" throughout Philippine society.

In a short interlude, She explained how Rodrigo Duterte, the Philippine president, was notorious for his abuse of state power, and for tyranny against critics of his regime. During the President's authoritarian rule, a draconian zero-tolerance drug policy devastated the country's democratic functioning

The speaker explained how Rappler's reporting standards allowed it to expose the wrongdoings of the government. Maria was also influential in making the public aware of Facebook's risks, and the ways it can distort facts and sway public



opinion.

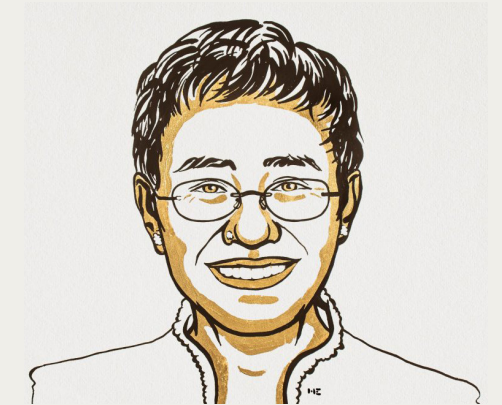
As she did earlier, she stressed the importance of freedom of expression in a democracy and brought attention to the fact that governments and corporations are able to manipulate facts to their benefit

In her quest for the truth, she overcame personal attacks, abuse on social media, arrests, and legal hurdles. Ressa thus made a name for herself as a fearless defender of freedom of expression and was rightfully awarded the Nobel Prize

In this section, she cited a few quotes by the Nobel Prize winner, one of which was particularly noteworthy. - "If you want to rip the heart out of a democracy, you go after the facts. That's what modern authoritarians do. You lie. All the time. Then, you say it's your opponents and the journalists who lie"

Namrata Singh then spoke of Dmitry Muratov - the renowned Russian Editor who shared the Nobel Prize for his similar contribution - upholding the spirit of democracy despite rising threats eroding away fundamental principles.

She began with his early life - Dmitry person initially served in the Soviet army. Later, he worked as a correspondent and headed a local tabloid. He later left to start his own newspaper, Novaya Gazeta, with the goal of



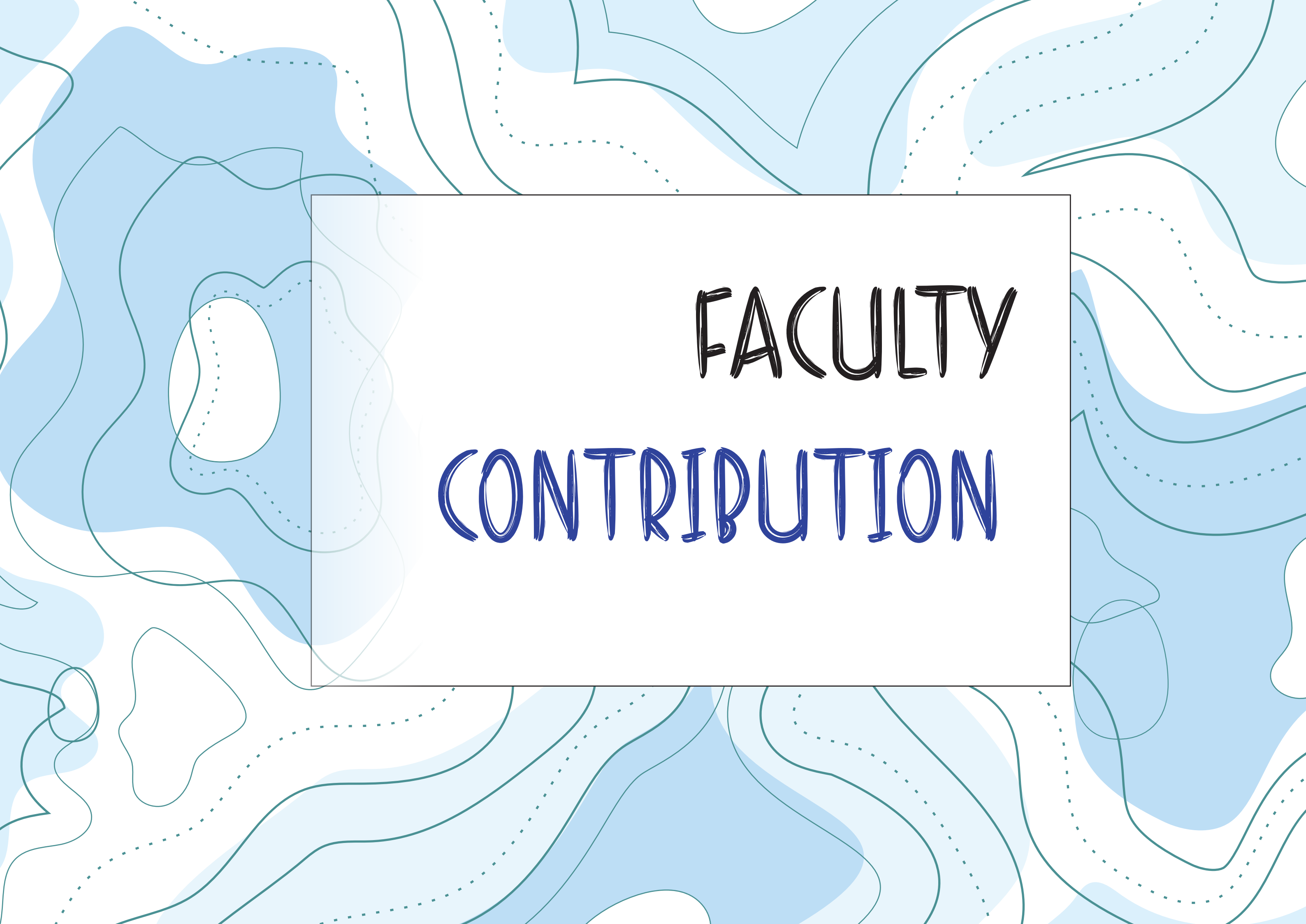
becoming an independent and honest source of information. She explained how Novaya Gazeta was a very influential newspaper - it was critical of the authoritarian government in Russia. His newspaper exposed several instances of corruption and electoral fraud. His newspaper also played an important role in uncovering human rights violations by military officials

The consequences he faced were legal actions against his newspaper and threats from the government. Many of the reports were harassed, and some even brutally murdered. Muratov was nonetheless motivated enough to search for the truth despite these obstacles.

In pursuit of truth even in the face of such grave threats, his indomitable spirit won him the Nobel Prize. The Nobel Laureate in his acceptance speech stated with great humility that, he didn't deserve the Nobel Prize, and the journalists who lost their lives in this endangerment were the ones truly deserving it. Dr Singh went on to his famous quote. "If there's a future for this country, there's a future for independent media"

With that, Dr Namrata Singh concluded this inspiring and informative presentation. She hoped to meet the audience again in person in the future. In closing, the Science Club co-ordinators thanked the speaker and concluded the exciting Nobel Evening lecture series.

PEACE

The background features a complex pattern of overlapping, wavy lines in various shades of blue and teal. Some lines are solid, while others are dotted. A large, white rectangular box is centered on the page, containing the text.

FACULTY CONTRIBUTION

Seafloor Spreading and an Expedition in the Central Gulf of California

- Sudipta Sarkar

The oceans have been here for almost four billion years, carving the coastline, driving the climate, and controlling life's destiny. The knowledge of the underwater world comes from numerous marine expeditions probing the ocean's deepest secrets. The expeditions are conducted on marine research vessels that carry the scientific team with their equipment enabling them to research multidisciplinary topics, such as marine geology, geophysics, biology, oceanography, etc. For example, we could map the symmetrically aligned magnetic stripes around the mid-ocean ridge on the ocean floor in stunning detail. These patterned stripes help to infer ocean spreading at the mid-ocean ridges.

We now know that extensional forces crack open the continents. As the continents fall away, a new ocean forms. The ocean floor material is made up of basalt that forms at the mid-ocean ridge, where hot magma rises. The magma reaches the surface, solidifies, and forms a hard basaltic crust. At the ridge, the crust spreads away.

The spreading centre is the boundary between two diverging plates. Along the volcanically active mid-ocean ridges, water seeps into the Earth's crust through cracks and fissures and becomes super-heated by Earth's magma. As it is heated up, it rises to the ocean floor. The water picks up dissolved minerals along its journey, and finally, the water exits the oceanic crust creating hydrothermal vent structures.

Hydrothermal Vents-Oasis of life in the dark

The discovery of hydrothermal vents forced us to rethink how life can happen on Earth. Until then, we had thought all life was dependent on sunlight. The hydrothermal vents suggested that there is an entirely new ecosystem that thrives in the deep ocean. Vents that emit hot mineral-rich water changed our understanding of the world as we know it. The organisms, like giant tubeworms, are clustered around the vents that emit plumes of super-heated water enriched in chemicals. The lifeforms use toxic chemicals to convert to life energy. The longevity

of a hydrothermal vent is dependent on the magmatic heat source fuelling them. Therefore, thermal energy plays a critical role in sustaining the lifeforms at greater depths.

Sedimented Ocean spreading centre

Sediments brought in by terrestrial rivers into the ocean can influence the subsurface temperature field. The sediments are colder and absorb the heat brought up by magma. In a sedimented spreading centre, sediments prevent magma from extruding on the surface. Magma forcefully intrudes into the sediments and cooks up the organic matter, converting them into methane and carbon di-oxide. These gases can be emitted rapidly and violently at the seabed. Rapid injection of methane and carbon di-oxide from the ocean into the atmosphere could enrich more greenhouse gases, leading to global warming. Such processes likely happened ~55 Million Years ago (Palaeocene-Eocene boundary) when the Earth's climate warmed up by 5°C. Numerous hydrothermal vents, which are now buried, are found in the Norwegian Sea in the North Atlantic Ocean. They bear evidence of the volcanic episode during the initial period of North Atlantic spreading.

The present is the key to the past

Are there any present-day examples of hydrothermal processes that can help us understand their role in supporting life and driving climate change? The answer is yes. In the central Gulf of California, mantle-derived melts intrude into the carbon-rich sedimentary layers and cause the release of methane. Recent marine expeditions followed by ocean

drilling provide invaluable information about the spreading centre in the central Gulf of California. During the expeditions, we measured the seabed heat flow and captured seabed images. They help to map out the vents and determine the temperature anomalies. The vents have a lifespan controlled by magma and the time taken for its solidification. The magmatic intrusions create large thermal and chemical gradients in the subsurface. The chemical and thermal energy support microbial communities that thrive in the diverse ecological niches at and below the seafloor. Around the extinct hydrothermal vents, there is evidence of seep carbonates. When methane is emitted through the vents, carbonates are precipitated at the seabed. Chemical analysis of these carbonates provides more information about the timing and methane flux. These crucial pieces of evidence help understand how carbon is recycled back to the ocean and atmosphere from the geosphere.



MORE IS LESS ?

- M. S. Santhanam
(Associate Professor, Physics Department)

Scientists are expected to keep abreast of current research developments. On the face of it, this might seem like the easiest thing to do. How does one do it? By attending seminars, reading recently published books, articles in journals and periodicals. Without even looking at the data, it is clear that the number of active scientific journals and number of published articles are increasing at a faster rate. For those who need the numbers, here it is -- journals grew by about 3% per year for the last 200 years, but now it stands at 5%. Growth of articles is even more staggering. The open repository of scholarly articles, arXiv, hosted at Cornell University, received about 30000 articles in the year 2000, while it received 180000 articles in 2020. This is about 25% annual growth rate. It is in this backdrop that one understands the magnitude of what it means to keep abreast of recent research developments.

Historically, keeping track of scientific literature was not such a major issue for scientists. The first scientific journal "The Philosophical Transactions of Royal Society" was started in 1665. During the next two centuries, the growth of journals was

somewhat slow. Most of the prestigious journals of today, "Physical Review Letters" for example, are less than 100 years old. But more importantly, it represented an unhurried era that probably lasted until very recently. It was the time when journals were actually printed on paper. Even today many are printed on paper, but easy internet access has effectively made them irrelevant. To a practicing scientist, this means that the information was coming through slowly; one takes more time to assimilate it, and even more time to work on follow-up ideas. Almost until the early 20th century, papers would not even carry an abstract. In cricketing terms, it was a test match era of sorts. Just as you would watch the game patiently for 5 days to know the result (it could even be a draw), you also need to read the full paper to know what the results are. That was the bygone era.

In the current era of T-20 matches, one needs to assimilate new papers and think ahead, metaphorically, at the speed of light for what may be termed "break-through ideas". For instance, about 290 papers appear every week in the condensed matter physics section of arXiv

alone. It is probably not unreasonable if the situation just demanded that a contemporary scientist shed some laziness and work a bit faster. It is more than that. With increasing numbers of journals and papers, add to it the video lectures and conference talks and other popular social media information, what started as a trickle some two decades back has now become a flood of ceaseless information. To handle this excessive information, there are online tools and mobile apps that promise to help us keep our heads above the water level. Some of these apps even use machine learning tools to 'learn' what we like and dislike, and will filter and show us those papers that, in its opinion, are relevant to our work. To make matters worse, fake and predatory journals and some scientific societies have muddled the scene for crass commercial considerations.

Faced with an overdose of scholarly literature in science, increasingly one tends to miss out interesting papers and results. Sometime back, a colleague told me that he reads only those papers that helps him carry out the immediate work. Imagine that 100 years back, Einstein had the time to read a paper he received from an unknown person in India, translate it and got it published. It led to Bose-Einstein statistics. Today, is too much choice, too much information becoming counter-productive? Is it leading to information fatigue? Is more information, in reality, less than optimal? Perhaps, there is no easy solution to these issues. There could be sustainable solutions if instead of focussing only on numbers and growth rates everywhere -- ranging from number of papers, impact metrics to more profits -- we focus on more substantive issues central to science and research.



THE VALUE OF EDUCATION

- Dr. K. P. Mohanan (ThinQ)

If you are reading this, you are likely to be a BS-MS student at IISER Pune. I would like to ask you a simple question. What are the chances that five to ten years after you have completed the current program, you would require to use what you have learnt during the program in your career, profession, or personal life?

I am pointing to the need to reflect on the value of what you learn in an educational program. A system of



education in which a program does not help you learn what would be of value to you in your life after graduation is dysfunctional.

Do you think what you are learning now

will be of value to you?

To answer this question, you would need an estimate of the percentage of students who get their MS degree from the IISERs and end up in a career or profession that requires them to use what they have learnt. An Internet search on this gave me no answer. So, as an alternative way of thinking about the question, let me suggest two scenarios:

Scenario 1: Roughly 25% of the graduates of Institution X need to use what they have learnt at X in their life after formal education; the rest do not.

Scenario 2: Roughly 75% of the graduates of Institution X need to use what they have learnt at X in their life after formal education; the rest do not.

If the situation is comparable to scenario 1, the program is a waste of time for the majority. If the facts are close to scenario 2, the design of the program is unfair to the minority.

The problem that I am raising here is a general one concerning the design of higher education. In a talk that I gave at an event in a Rotary Club, I asked the audience, most of them with degrees in Engineering:

"How many of you have learnt calculus?"

Except for one or two out of a hundred, all hands went up.

"How many of you have learnt how to solve quadratic equations?" All hands went up. Then came the difficult question:

"How many of you have had to use calculus or quadratic equations after completing your formal education?" Three hands went up. Did the others waste their time studying what they do not need in their personal, professional, or public lives after their formal education? Would they wish their children to waste their time too? The members of the audience looked at one another. They said nothing.

I then asked:

"How many of you have heard of clinical depression?"

I made it clear that I was not talking about ordinary 'depression' or sadness but an illness of the brain that often calls for medical intervention. Only about three or four hands went up. I then gave a brief exposition on clinical depression, and how in extreme cases, a patient often attempts suicide, and many succeed. The number of suicides among students in India has been rising at an alarming rate.

(See, for instance: the report in Hindu "Student suicides rising, 28 lives lost every day," at <https://www.thehindu.com/news/national/student-suicides-rising-28-lives-lost-every-day/>

[article30685085.ece](https://en.wikipedia.org/wiki/Suicide_in_India) and the Wikipedia entry on "Suicide in India," at https://en.wikipedia.org/wiki/Suicide_in_India)

After this introduction, I added something straightforward: "It shouldn't come as a surprise that at least one or two of you sitting in this hall may have a son or daughter who suffers from clinical depression. They might be contemplating suicide, and perhaps may even be successful in their attempt. Shouldn't the educational system have given you at least a rudimentary knowledge of this deadly illness of the mind-brain, its typical symptoms, ways of detecting them, and strategies for helping those suffering from this illness?"

This time, the audience was in a panic. They wanted me to tell them more about clinical depression. And I refused, saying, "All of you have university degrees, so you must be able to find out on your own. Perhaps you can go to Youtube and watch Stanford Professor Robert Sapolsky's lecture on clinical depression."

The point I am making here is not about quadratic equations or clinical depression but the irrelevance of our education system for our personal, public, professional, and intellectual lives, including research. All that the system empowers you to do is gain

admission to the next level of education, say, from school to college or from a Master's to a PhD. Anything of value in our subsequent life, we must learn outside the system.

This is not to say that education should be restricted to those forms of learning that have practical utility in one's everyday life: for instance, how to invest wisely, how to detect clinical depression in someone, or how to be attractive to the opposite sex.

Some learning outcomes that would be of value throughout life, which education would do well to aim at, are these capacities:

- to learn from documented sources of knowledge without having to depend on teachers and classrooms;
- to read critically, which calls for the ability to:
 - a. identify the central claims of a piece of writing;
 - b. identify the arguments in support of the claim; and
 - c. critically evaluate the claims and the arguments;
- to engage in inquiry in a wide range of academic domains, making connections across them and integrating ideas, and so on.

My point is, the existing forms of mainstream education, whether of high prestige or low prestige, do not aim at learning outcomes that ought to be highly valued, whether for practical life or intellectual development.

Is there a solution to this problem? Yes, there is. To transform formal education to provide what is of value in our personal, professional, and public lives, we need to change what our examinations and tests probe into and what is taught in textbooks and classrooms. Examples of learning materials for this strand of education are available in:

Articles: <http://www.thinq.education/articles>

Youtube videos: https://www.youtube.com/c/ThinQ_ed/videos

Webinars: <http://www.thinq.education/events>

For the system to pursue the strand of education represented in the materials given at the above sites, we need capable and willing humans in positions of power. Perhaps when the next generation, namely you, learn on your own what is of value, and some of you get into positions of power, you would have the opportunity to change the system as parents, teachers, educators, administrators, and members of the government.



INTERVIEWS



1. What keeps you motivated to pre-serve Sci-Hub safe and functioning? Fighting through the number of legal issues that you have faced so far (and are still facing) must require massive amounts of mental strength and motivation. Is there something besides the root cause for establishing Sci-Hub that pushes you?

When Sci-Hub just started, it got a lot of support from people. Many people were grateful they could download papers for free. It motivated me to work further on Sci-Hub. Now, after ten years, Sci-Hub is a part of my life, and more than half a million people are using it daily. Does it require additional motivation? If I destroy Sci-Hub, I destroy myself and many people who depend on it.

2. In your opinion, what can students like us do to contribute to the cause of Open Science while also taking care of safety and security concerns?

That is easy: Publish in open access only, and stop supporting paywalled journals with papers and reviews.

3. There are some scientific journals that Sci-Hub still cannot access. Do you plan to work on them too?

Of course. The goal is to make all scientific literature ever published available on Sci-Hub.

4. What is the current risk profile of Sci-Hub, Libgen, etc.? Is there any chance that soon, we might see some kind of action being taken by lawmakers worldwide to restrict these sites?

They have been taking action to restrict websites in various countries for several years now. I do not think they are going to

stop all of a sudden until they are defeated.

5. What are the safety measures taken to protect the database of these sites if, at any time, a malicious attack is made to breach the servers/database and erase content/make the website inaccessible?

That is not possible to erase the content, there is always a backup copy, and additionally, now the Sci-Hub database is also stored in a decentralised mode on torrents.

6. Do you see any encouraging signs for Sci-Hub in the context of legal issues in the recent past? Do you anticipate any in the near future? (not necessarily pertaining to a specific country)

Yes, Sci-Hub recently has got legal protection in India. That is the first time Sci-Hub is being protected in court - and has all chance to win the case!

7. What can one do if Sci-Hub is blocked in their country/region? Has Sci-Hub taken any actions to circumvent such bans?

It is possible to use VPN or TOR Browser to circumvent any government censorship of websites.

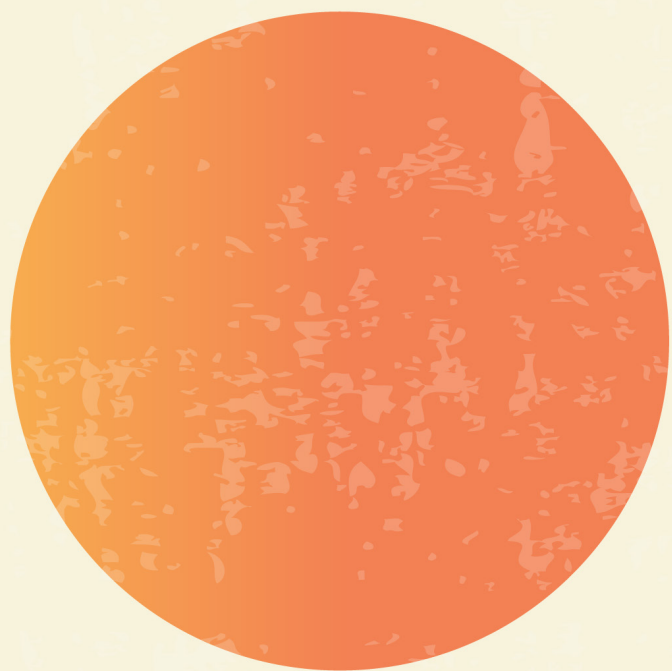
8. Does managing Sci-Hub have maintenance costs? Do donations suffice, or do you receive funds from other sources as well? Have there been any legal repercussions for Sci-Hub adopting Alipay for donations?

Sci-Hub is running on donations only, and it does not have other funding. Recently I have added Alipay, and it works well.

INTERVIEW WITH MS. ELBAKYAN



Sci-Hub Founder



9. You have studied several things, from computer science to linguistics to the history of science. Could you elaborate on what led you to pursue so many different fields? How has your worldview changed throughout being exposed to so many diverse lines of thought?

These fields are not different at all because all of them study information and communication. Language is the primary medium for communication, and linguistics is the field that studies it. Science is a pursuit of correct information about the world; Sci-Hub is a tool to help people obtain information ... and generally speaking, separation of different fields in science is an artificial thing.

10. How popular do you think Sci-Hub is in India compared to other countries? Has the Indian user base seen an upward trend, especially during the pandemic era?

In India, there are currently about 700-800 thousand unique visitors per month. China is about 800 thousand to 1 million sometimes. All other countries have much fewer users. The next ones are Brazil with 400 thousand users, the United States with about 350 thousand and Indonesia with 250-300 thousand users.

11. What significance does the Sci-Hub logo hold? Why did you choose a raven?

I was looking for a picture with books and a key on Google to communicate that Sci-Hub is a key to knowledge... then I found this picture, with a bird on books holding a key, and took it to use for Sci-Hub. Raven is a symbol of knowledge and intelligence in various cultures. For example, in Norse mythology, there are two ravens Huginn and Muninn, that represent 'memory' and 'thought.'

12. In your opinion, what are subtler ways (compared to inaccessibility of research) in which someone's economic situation hinders their scientific/techni-

cal ambitions, and what can be done to address them?

One research found that the children's IQ was lower in lower-income families because they do not get the same nutrition and treatment as kids in high-income families. Moreover, educational opportunities are scarce for poor people, etc. To address all disadvantages that come with poverty, we need to build a communist society.

13. According to you, what will an ideal scientific research environment look like? How will the researchers communicate their work among each other, to the public, etc.? How will scientific rigour in their research be ensured?

Ideal: without publishers! Rigour can be ensured by scientists checking the work of each other. Science communication must be distributed and decentralised. It shouldn't be as today when a single publisher has control over thousands of academic journals.

14. On a lighter note, if you could have three wishes, what would they be?

OK, 1. Sci-Hub made legal 2. Humanity discovers a secret to immortality 3. Turn me into a God
Ha-ha!

15. This is a million-dollar question. How exactly does Sci-Hub get access to these restricted publications?

But I answered it many times. Sci-Hub downloads papers through various universities that have subscriptions to the journals. For example, there is a student inside a university or a professor. They have a personal password that allows them to access journals that their university subscribed to. Sci-Hub takes such passwords and uses them to download papers from these journals and store them in its own database that is accessible to everyone.

1. How would you describe your journey being in the field of science? What inspired you to do research?

Dr Bruce Alberts: I became a Scientist because I was a pre-medical student at college, and I couldn't stand the afternoon laboratories of Physics or Chemistry, and I felt like I was "cooking". We had to follow certain steps, but that wasn't science mainly. It continued for two years. I had a laboratory even worse in a course called 'Physical chemistry', and after one semester in the lab, I said I couldn't stand this lab anymore. I liked the course, but the lab had nothing to do with the course and how can I get out of taking a lab, and they told me this at Harvard University- I could work in a research lab that would substitute and that made all the difference. Soon I got into a research lab, and I realised I liked science and discovered what real science was. I soon decided that I wouldn't be a medical student any longer and would get a PhD. Now I believe that every first-year student should spend some time in a laboratory and be exposed to real science and not "cooking". I feel that all my graduate students couldn't become scientists if they never did work that they hadn't ever thought of. Until they hadn't had an idea and they made it work, they couldn't become scientists. They gained the self-confidence that they could be a scientist on their own. But you cannot make scientists by having them follow instructions and do cooking because science is not something you do by a form of science like art. Good scientists learn how to make a clever strategy different from what other people are doing and can make a difference. In my opinion, life is lovely being a scientist, because you could get paid to solve significant problems that interest

you. So, it's a great privilege to be a scientist. There are so many things about Biology which we don't know. You know that you should be able to take risks and try something new.

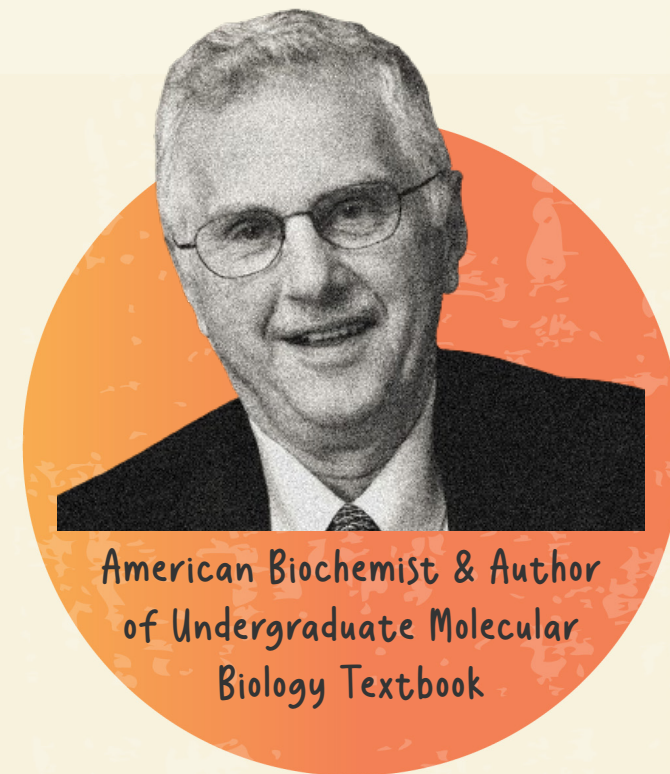
2. What have been the various developments in science in the last few years?

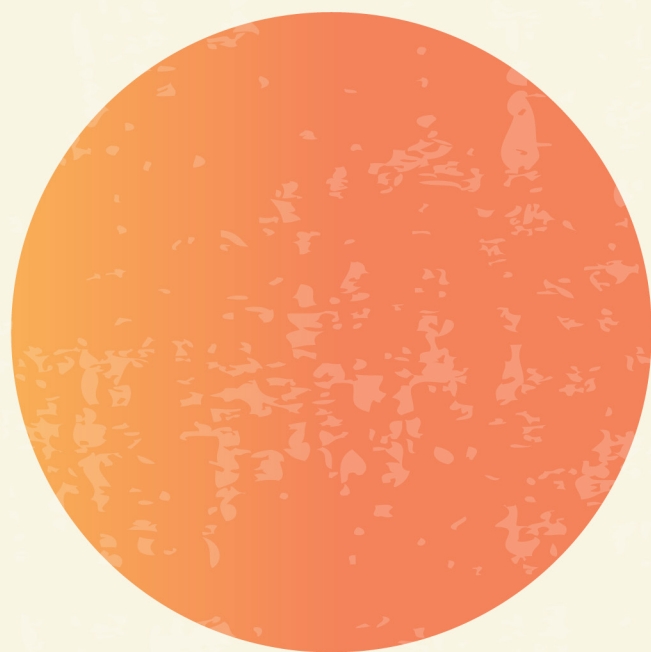
Dr Bruce Alberts: In the last thirty years, there has been a lot of research going on in the psychology department. There have been extensive experiments done in college classes investigating controls - what's the best way to reach out to students and make them excited about science. But most professors are not paying attention to that. The National Academy of Sciences in the United States has published around 10,000 reports on its website. One of those reports is called- "Reaching Students"- what research says about teaching undergraduate science and engineering.

3. What about biology fascinated you the most that you chose to move away from pre-med and continue in the domain of biology research?

Dr Bruce Alberts: I have had the privilege of looking at so many unsolved problems in molecular biology. The good news for young people is that there are beautiful things for you to do in science where we need you to be creative and make contributions. The bad news is that some of the older scientists set rules that make younger scientists feel forced to do obvious things and are sure to work.

INTERVIEW WITH DR. BRUCE ALBERTS





4. What, according to you, is the most beautiful experiment in science / favourite pieces of work?

Dr Bruce Alberts: I write a cell biology textbook every few years. We just finished the seventh edition of our big book. I wrote a piece in science in a magazine recently in 2018. Harold Varmus, Shirley Tilman and I wrote a bit about how to support science. We admire the European research council. It funds scientists to take risks and evaluates them with an abroad group of expert scientists who try to judge – is this a significant problem, is this a good idea- this person can solve problems. In the United States, decisions about science funding are made by a narrow group of scientists who are experts in something, and then they ask whether this is going to work. My colleagues and I wrote an article urging the United States' National Institute of Health to make what we call a level playing field for young scientists. They have half the grants for doing what you've already been working on and that you think will likely work, and those are the things that generally get funded, but the other half of grants are reserved for the projects like the ones that the European research council funds with their so-called 'starter grants'. They look for new ideas, for taking risks for something that, if it works, will make a big difference, and so we have a long way to go with that.

5. You've done your graduate and post-graduate research at Harvard. Do you think the institution plays a crucial role in nurturing that scientific research-based mindset?

Dr Bruce Alberts: Harvard is overrated

(laughs)! There are many good places- if you want to go to the graduate school where there are good programs and Harvard happens to be so famous for other reasons and not only because of their science. Most of them are in European countries also. I know the best course offered at my university- UCSF. When you get accepted into the graduate program, you don't know who your professor would be. What I would call a good graduate program in the United States is that you take some courses and do a lab rotation in the first year itself. You rotate through three different labs, and every quarter you do a different lab. You are not allowed to select your PhD advisor until your third rotation so that you have three experiences, and then in June or July of your third year, you say I want to work for this professor. By that time, you understand what the professor is like and what he expects from his students. I think you should find a graduate program that allows the students to rotate through different laboratories in your first year and then make an important decision as to who you are going to work for as a professor. Make that with some knowledge and experience and not just guessing. I always advise students to choose a young professor who has a small lab so that the young professor will pay attention to you. If you go into a huge lab, you are just lost. I don't believe in large laboratories. Laboratories shouldn't be bigger than to accommodate not more than 10 or 12 people. Some of these large labs do not provide suitable training environments for students.

6. How did the entire process of writing "Molecular Biology of the Cell"

begin and unfold? How long did it take? What were the challenges you faced, especially when the internet was not a one-stop destination for all answers?

Dr Bruce Alberts: I have been writing a textbook for 43 years, and the good news is that it is stolen, and everybody can get it as a free pdf. My co-author was Keith Roberts, and I'm in London. So, he is the one who does all the drawings in the textbook. (He also called Keith Roberts on the call for a few moments and made him meet the students.) In the olden days, people in India had to buy the book, and it was too expensive. It was our second edition, and we had a particular company in India print the textbook in black and white on inexpensive paper, and it was available in India. But they never did it again because some people in India sold those textbooks back to Europe and the United States. They didn't stay in India so that the publisher wouldn't do it again, but in the later years, we had the internet and all the people putting up our textbook as a free pdf. It's illegal, and the publishing company doesn't like it because they don't sell as many books. Now that we ask in India how many people have our textbook, it's good to see a large number. At least the authors are happy. The hardest part of a textbook is how much you leave out because there's so much known, and every year, we have to take out 10% or 20% of our book and add new things, and that's the genuine hard part of the textbook.

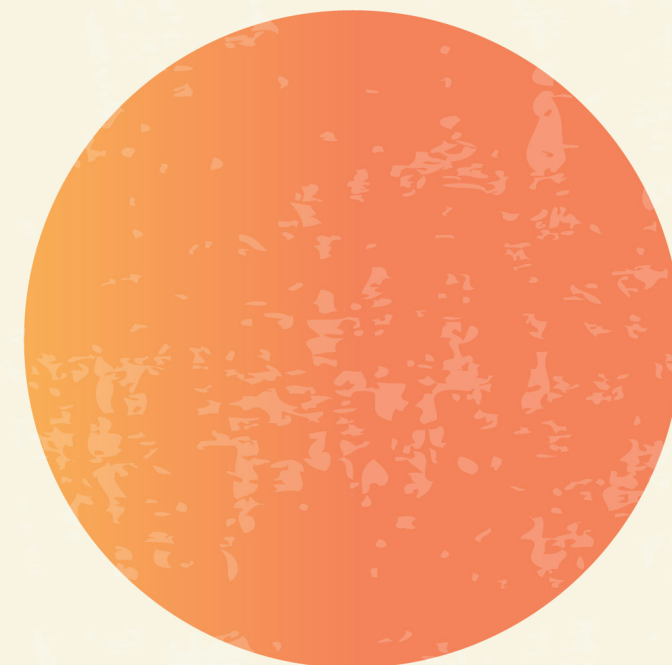
7. Having taken up various administrative positions, which changes can be made to refine the education system? And what are your thoughts on the present methods of teaching, learning, and evaluation?

Dr Bruce Alberts: We know a lot from scientifically based education research

about what makes students learn and what's good teaching and what's not good teaching and we know that you know a professor standing up in front of a class with powerpoint slides and talking all time is not the best way to learn for students. Now the professors are old and they'll probably learn that way so they were selected to be people who could learn well from powerpoint presentations. But we know that active learning is far more successful in creating people who really understand science. More than that, we know from research that there are different kinds of active learning. We know that the most effective forms of active learning involve you interacting with some other student to make sense out of something. It's amazing to understand the other person's point of view and then you remember. If you just memorize a fact from the powerpoint slide, take an exam and the next year you may not know anything about that!

8. If you hadn't become a scientist, what would you have chosen as your career?

Dr. Bruce Alberts: I would have liked to have been a high school teacher probably teaching science to students. I believe teaching is most important to society. But we don't value teachers enough, we don't pay them enough but it's the most important profession for the future to have a good teacher.



INTERVIEW WITH DR. MIHIR METKAR



Primary Contributor to
Moderna's COVID-19 vaccine

1. What motivated/trained you to work in the field of vaccination?

A: I am part of Moderna's platform division. We develop the tools that are used as therapeutics. So, I don't directly work in the field of vaccination.

2. How does it feel to gain this success seeing how this remarkable method helped in immunizing a lot of people?

A: Just happy I was able to do something.

3. What skillset/benefits you gained from your experience in being a project assistant under Dr. Kundan Sengupta at IISER Pune in 2010?

A: Kundan was a really good mentor. He always encouraged me to come up with the ideas and think about experiments we could do to answer them.

4. What inspired you to transition from academia to industry?

A: Knowing that science is the same whether you are in academia or industry. Academic research helps lay the foundation for therapeutics and industry figures out the structure. Industries have basic science divisions and a lot of labs do translational research. You can find what you love in any space. Also, industry paying more also helped the decision. :)

5. What are the differences you experienced in academia and working in a pharma company?

A: In academia you are driving your own project. The direction and pace are defined by your mentor and you. You may have limited resources, but you can change the direction of your research any time. In industry it is a bit more structured. You have some topics of interest outlined at the beginning of the year and you have the freedom to develop projects within that space. Also, the projects have a shorter life (1-3 yrs). Also, you usually collaborate with multiple people. You may

have lot more resources, but you need to convince multiple stakeholders that the idea is worthy to be tested.

6. What are the different fields, in which people work, in Moderna?

A: You can find this information on Moderna's website.

7. What are the applications of ribonuclear proteins(RNP) complexes in the real world? (your current field of research)

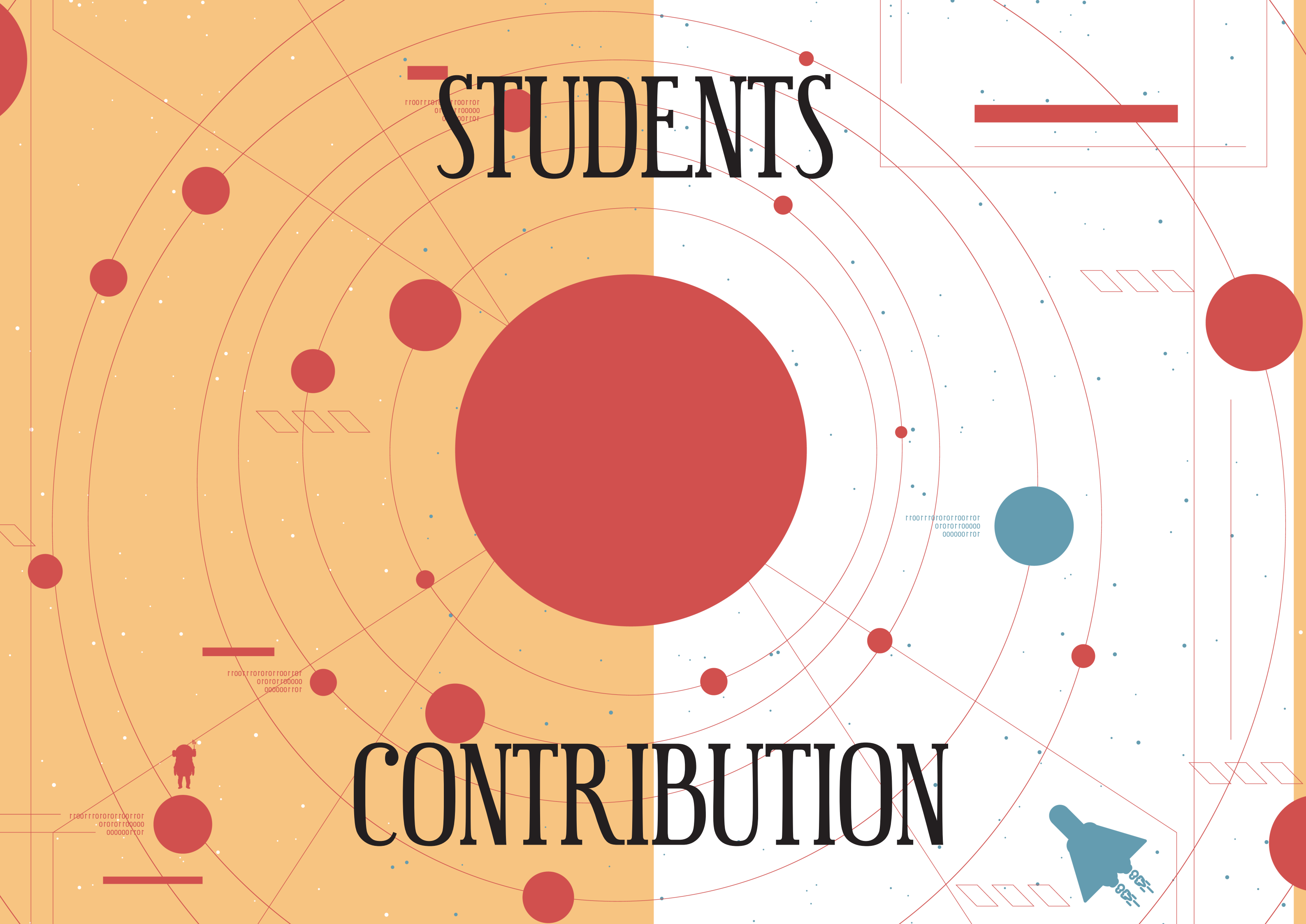
A: Lots! mRNAs or any RNA is never naked inside a cell. It is always complexed with a protein. So targeting either as a therapeutic is a valid approach. Therapeutic mRNA once delivered needs endogenous proteins to translate. miRNAs require Ago protein to be active. There are other companies targeting RNPs with small molecules.

8. What path would you suggest to people who are interested in bioinformatics and data analysis?

A: Sorry, I didn't get this question. Generally, do what interests you. There are highs and lows in every field, but aim to do something that makes you happy in the long run.

9. What do you aim to achieve in the forthcoming years?

A: My career is in it's infancy. I have a lot to learn about my fields of interest and need to gain a lots of new skills. I enjoy thinking about scientific questions and coming with ideas/methods to answer them. Hopefully I will keep getting better at it as I gain more experience.



STUDENTS

CONTRIBUTION

Risks Associated with Decarbonizing the Economy

–My Research

- Suryadepto Nag

In my research with Professor Siddhartha Pratim Chakrabarty at the Indian Institute of Technology Guwahati and Professor Sankarshan Basu at the Indian Institute of Management Bangalore, we found that this is true in part. Most of the companies in our dataset (firms in the S&P 500 index) had indeed reduced their carbon footprint between 2016 and 2019. However, the reduction was small.

A small decline in carbon footprint will not help much in curbing accelerated climate change, and therefore may warrant stringent action from government agencies. The action could have different degrees of severity, ranging from carbon taxes levied on companies that emit, or outright interdicts on products that pollute. Such government action will hurt investors if they do not reduce their investments in high-carbon companies.

Scientists in the past have studied whether investors are aware of such risks, given that investors continue to invest in carbon-intensive stocks. It has been found in many instances that stocks of polluting firms offer better returns currently than others. This additional return on top of the intrinsic market value of the firm is a "premium" that is lucrative for investors to keep investing in the risky firm despite the risks. This is called a carbon-transition risk premium, i.e. it is generally assumed that such a premium exists because of the risks associated with investing in these firms.

One of the principal questions in our research was to quantify this risk for a future time, so as to study if such a risk outweighs the advantages of the premium or not i.e. if the risks of losses in the future are bigger than the short term benefits of

The recently concluded COP26 summit in Glasgow brought to focus the urgency with which the world needs to work to reduce its carbon footprints. Unfortunately, achieving a net-zero by 2050, will require the world to reduce emissions year on year by the extent that emissions were reduced from 2019 to 2020. However, we know that that was an anomaly, and in 2021, we have already surpassed the 2020 levels in terms of the net emissions in the atmosphere. Certain lobbyists around the world believe that decarbonization is best left to the corporations themselves - that corporations will envisage better strategies and build technologies that will assist them in reducing their carbon footprint drastically.





on google under the search of "From Carbon-transition Premium to Carbon-transition Risk."

The talk can be accessed from: <https://www.youtube.com/watch?v=pANGsb-pscZ8&list=PLAua0PJZLQo5A1x-VN8B0dA8Z5hfvVfK4j&index=3>

and drawing inspiration from an established model of pricing the premium of credit derivatives (annoying finance stuff that caused the 2007-08 financial crisis), we find the relationship between the risk premia and the SETRs.

Using these risk premia, we found that while on the short term the higher returns may be appealing, on the long term, carbon-intensive stocks are extremely risky and volatile (prices can vary by large amounts). Based on the probability density of the distribution of when the transition event occurs (the arrival process), there could be varying degrees of risk, which could even force some firms to go bankrupt. We also studied whether it was a good idea to invest in the firms hoping to exploit the premi-

um-risk tradeoff, and we found that for exponentially distributed arrival processes, it was not. For uniformly distributed processes, it didn't really matter, and for Gamma distributed processes the final solution was painful to find out, so we studied it numerically and found different cases on either side.

The takeaway, in my opinion, is that investors and corporations are riding on profits and earnings from a carbon intensive market. But if they don't reduce their footprints, governments will be forced to take action and strong government action from big economies of the world could potentially put investors in a soup like never before.

My paper on this can be found [here](#) or

DE-NOVO DRUG DESIGN : IN SILICO

- Sreyas Adury

Introduction

Computer-Aided Drug Design (CADD) is a vast topic that covers various stages of the normal process of drug development.

When a general protocol is done in-silico (i.e. in a computer), it has the advantage of being comparatively quicker and substantially cheaper and very easy to generalise to other systems. Still, it has the drawback of not accurately reproducing all experimental results.

The first step in performing de-novo drug prediction is identifying a target for the drug. Most drugs function by targeting a particular biomolecule (usually a protein) in the body to alter its action. Drugs are commonly involved in competitive[2] or allosteric[3] inhibition for protein targets.

Given a target and a molecule, the computer needs to tell if this molecule will act as a drug or not. The primary requirement is usually for the molecule to bind strongly to its target. So we need a method to guess the strength of the drug-target interactions computationally.

This is achieved with the help of **Classical Forcefields**, which are models that try to compute interaction energies between different molecules. Classical forcefields are designed to calculate non-bonded interactions efficiently. As most drug-protein interactions are non-covalent in nature, this is usually not a problem.

The model uses two non-bonded interaction calculations:

- **Lennard-Jones Potential:** This deals with short-ranged interactions and majorly models Van der Waal's forces and hydrophobic interactions.

$$E_{LJ} = 4\epsilon \left\{ \left(\frac{\sigma}{r} \right)^{12} - \left(\frac{\sigma}{r} \right)^6 \right\}$$



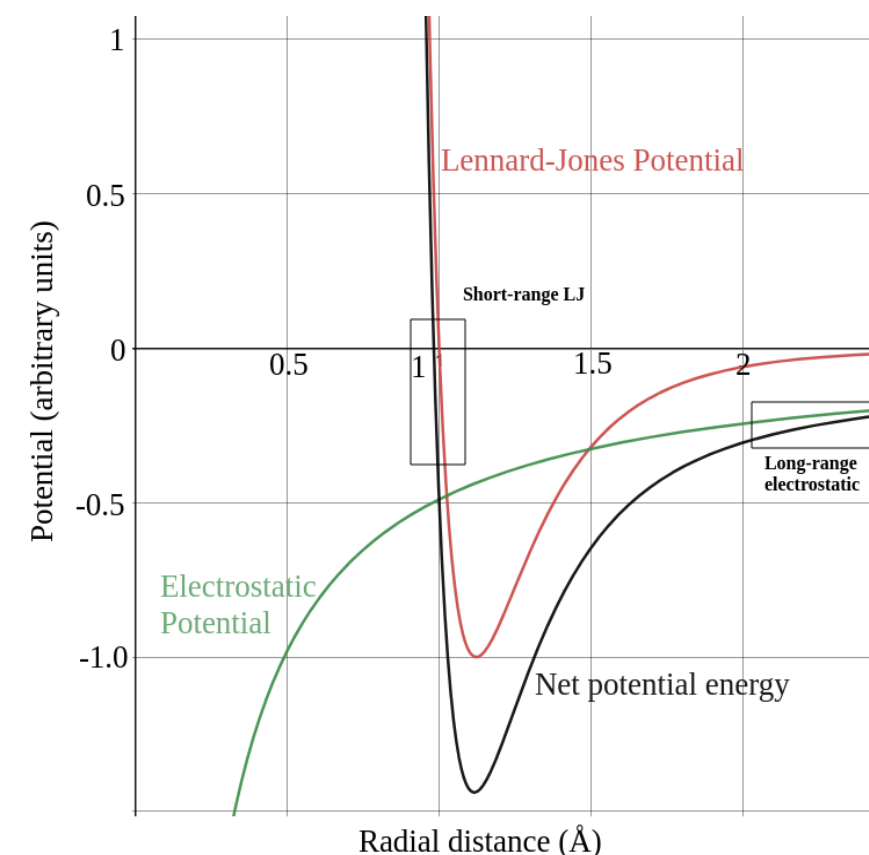
Electrostatic Potential: This is the standard electrostatic potential energy between two point charges. However, we use partial charges (charges less than one electronic charge) on each atom in these models to compute this value.

$$E_Q = \frac{Kq_1q_2}{r}$$

These potentials have the valuable property that each interaction is calculated between a pair of atoms only, and the total potential energy is just the sum of these terms, i.e.

$$E_{total} = \sum_{a_i \in Ligand} \sum_{b_j \in Protein} E_{LJ}(a_i, b_j) + E_Q(a_i, b_j)$$

Finally, these potentials depend only on 'r', the distance between the two atoms. The plot looks like this:



Relative position of a molecule

This discussion points to the fact that to compute these interactions, we also need to know the **positions** of the molecule's atoms relative to the protein and the exact 3D structure of the ligand when bound. Given this particular orientation of protein and ligand (called a pose), we can predict the interaction energy between these molecules. But how do we find this pose? This is where the process of **Molecular Docking** comes into the picture.

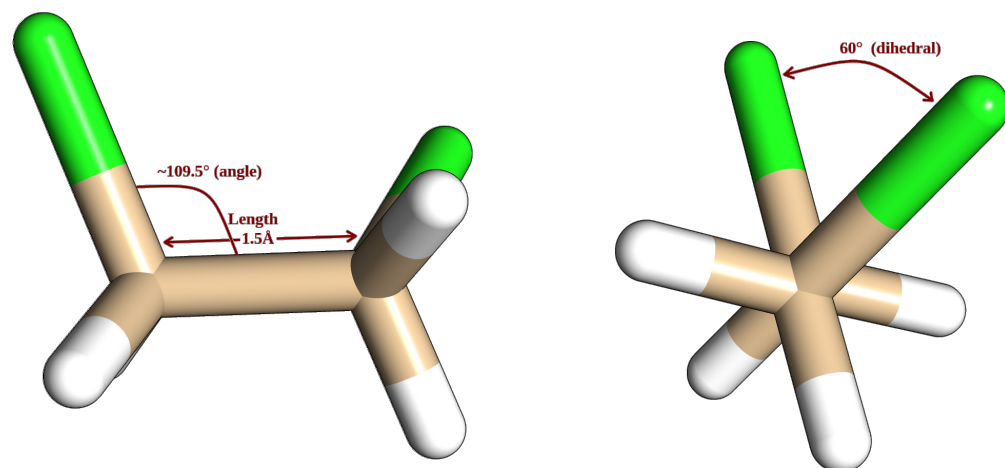
Molecular Docking is a significant problem and deserves an entire article to explain all the finer details involved in the process. But the fundamental idea is this:

We have the computer enumerate a large number of possible configurations for the ligand's atoms. Then we compute the interaction energy for each of these configurations and take the most optimal value.

3D Parameters of a Molecule

As we know, most molecules take up a specific 3D structure. 3D parameters used are also modelled carefully in the classical forcefields. These are:

- **Bond length**
- **Bond angle**
- **Bond dihedral**



In 3D, any unrelated three constraints can uniquely determine a position. Any change to these parameters results in a unique conformation whose energetics are captured by the forcefield parameters[5]. Hence, these three constraints tell us exactly how a molecule would organise itself in 3D space, and all it requires is the forcefield data. Knowing this 3D structure is essential for generating new molecules de-novo.

Abstraction to atom-types:

Forcefields are built on atom-types. Atom-types are classes of atoms that have similar polar/non-polar interactions (and hence similar parameters in the forcefield). Because of this, if we know the atom-type of some atom, we know:

1. Something about its immediate neighbours that affect its behaviour in chemistry
2. Its geometry
3. Its forcefield parameters

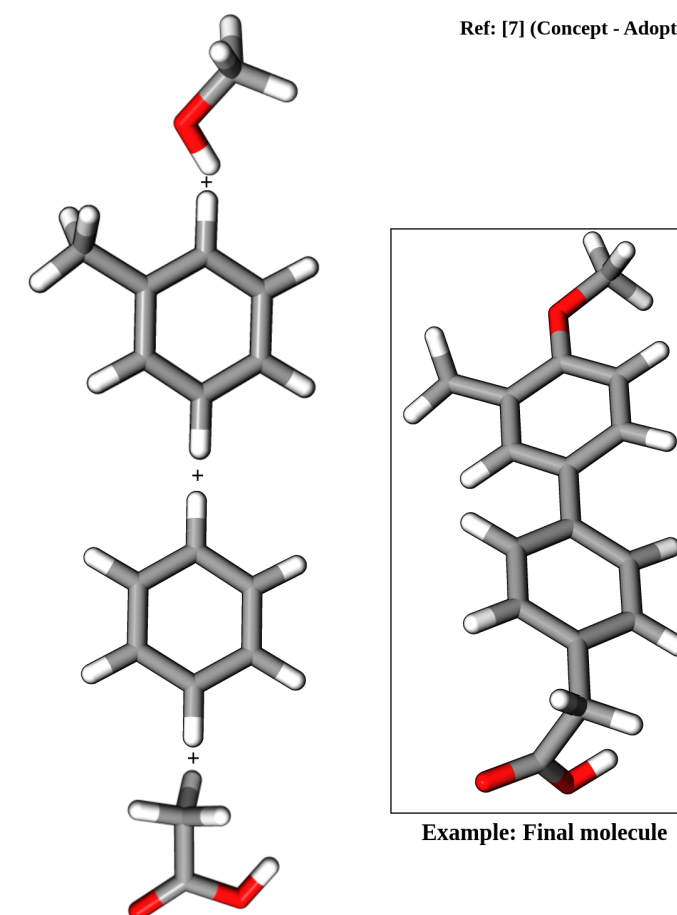
The 1st and 2nd points are vital for constructing a molecule from scratch, while the 3rd

point is beneficial to calculate interaction energies.

Armed with this information, computers can now try to construct molecules from scratch. There are two common ways in which this is done in practice:

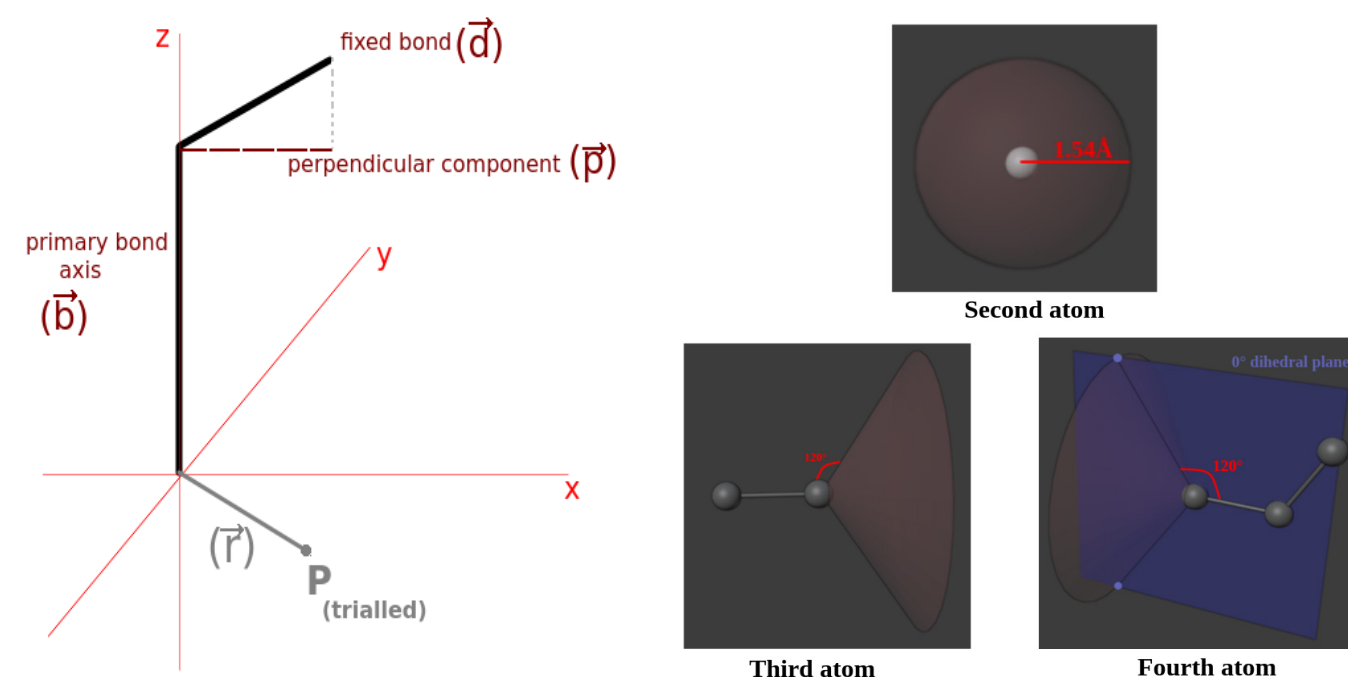
1. Fragment-based de-novo drug design:

In this case, we use a pre-constructed library of fragments for which the atom-types are already known. Then these fragments are pieced together (usually by removing one hydrogen atom from each component and joining them (See figure on the side)). The primary benefit of this method is that the molecules constructed by this method are likely to be more drug-like (i.e. less harmful, easily absorbed, etc.), something we haven't checked until now. The downside to this method is that the results are usually biased based on the initial set of fragments, and truly "new" molecules are rarely explored.



2. Atomistic de-novo drug-design[1]:

In this method, the molecule is constructed atom-by-atom. This is where we use the information from our forcefields. Instead of using just elements to define each atom, we use atom-types. Because an atom-type contains geometric information too, we know exactly where to place the next one. A 3D depiction is shown below.



In some cases, multiple dihedral values may be allowed. In such cases, all positions must be tried out, and we pick the more stable one with a higher probability. The exact calculation of this probability is beyond the scope of this article.

Looking at the broader picture of CADD, we have many other parameters to look at as well. We want our “ideal drug” molecules to be biologically safe, easy/cheap to synthesise, and have no adverse side effects.

Solving these problems only on a computer is difficult, but many heuristic checks are used. These involve inspections like Lipinski’s Rule of 5[7], which tries to predict if a molecule is “drug-like”.

Scope for improvement: The critical weakness of all the computational methods discussed is that sufficiently accurate methods are not feasible, and feasible methods are not accurate. If we can bridge this gap, the rate and quality of drug development would boost tremendously.

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The talk can be accessed from: <https://www.youtube.com/watch?v=CBZoq8Wtl-k&list=P LAua0PJZLQo5A1xVN8B0dA8Z5hfvfK4j&index=2>

A “Walk” Into Ants’ World

-Kaustubh Kulkarni

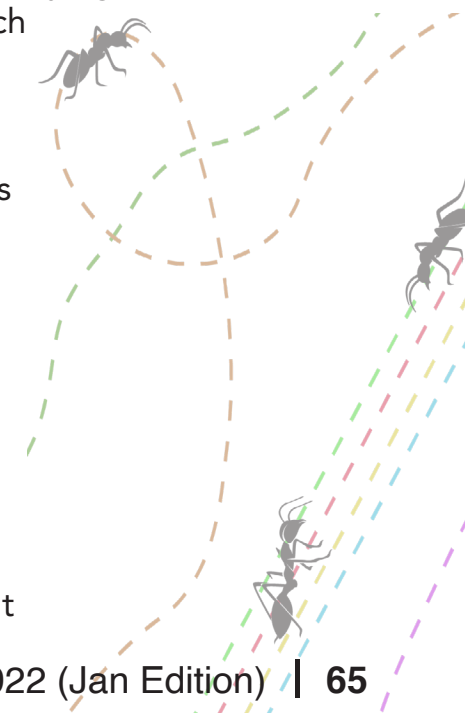
Measurement has been an essential component of human life since time immemorial. Humans measure length, time, speed, mass, temperature, pressure and numerous other quantities. However, as we now know, the art of measurement is not unique to the Homo sapiens. Several different species of organisms perform measurements, and ants are a striking example.

Ants are eusocial insects of the family Formicidae and belong to the order Hymenoptera. In the course of evolution, ant societies have developed the ability to solve complex problems. The ability to estimate distances walked is one such prominent example. [1] But before we discuss how they calculate distances, let us look at how ants find the shortest path to food.

A 1989 paper by Goss et al. [2] describes an experiment that led them to conclude that ants use pheromonal signals to find the shortest path to food. In their study on the Argentine ant, *Iridomyrmex humilis* (recently renamed as *Linepithema humile*), they designed a setup with two tracks to food from the nest— one short, the other long. They observed that although initially, ants chose their path randomly, a while later, the whole traffic concentrated on the shorter route. Did the ants consciously measure the distance? Further investigations by the scientists inferred that they didn’t. What was concluded is

as follows: At first, the choice of the path is random. Some ants go on the shorter one, while others take the longer route. They lay down pheromones as they walk, and other ants follow the trails of the pheromones. Ants walking on the shorter path need less time to travel to the food source and return. Thus, with time, the pheromone trail that accumulates on the shorter route is more substantial. This, in turn, persuades more ants to choose the faster road — speeding up the process and finally shifting the total traffic to the shorter route! This collective self-organising process is a beautiful example of autocatalytic amplification. [2] Research in self-organisation or ‘Swarm Intelligence’ has inspired computer scientists to develop powerful optimisation algorithms. [3]

Ants walk and not fly, making them better model systems for studying how animals navigate. [1] Research on Saharan desert ant *Cataglyphis fortis* shows how they travel in deserts by a method called ‘Path Integration’— and measure distances using a ‘step integrator. [4] Foraging ants follow complicated routes from their nest to food, but they follow a straight



path directly to their nest on their way back. This is called 'dead-reckoning' or 'path integration'. Path integration requires two inputs — direction and distance. The information on direction is obtained from the celestial compass of the ants. Various hypotheses attempt to explain how distance is measured.

One of them is the 'Energy Hypothesis', which suggests that the ants calculate distance using the energy required for locomotion. However, ants with weights attached to bodies measure distances as accurately as normal ants, disregarding the energy hypothesis. The 'Optic-flow Hypothesis,' which proposes that visual cues are used, is known not to play a significant role. The experiment mentioned below attempts to test the 'Pedometer Hypothesis'— an audacious hypothesis according to which the ants measure distance by integrating the number of steps taken! [4]

In this experiment, Wittlinger et al. trained ants to walk from the nest to a feeder in a linear channel. After one day of training, the ants were caught at the feeding site and transferred to a test channel aligned parallel to the training channel. On moving to this channel, the ants performed their homebound run. The scientists noted the point at which the ants switched from their straight path to a nest-searching behaviour— the distance where the ants believed their nest to be. Then, ants that

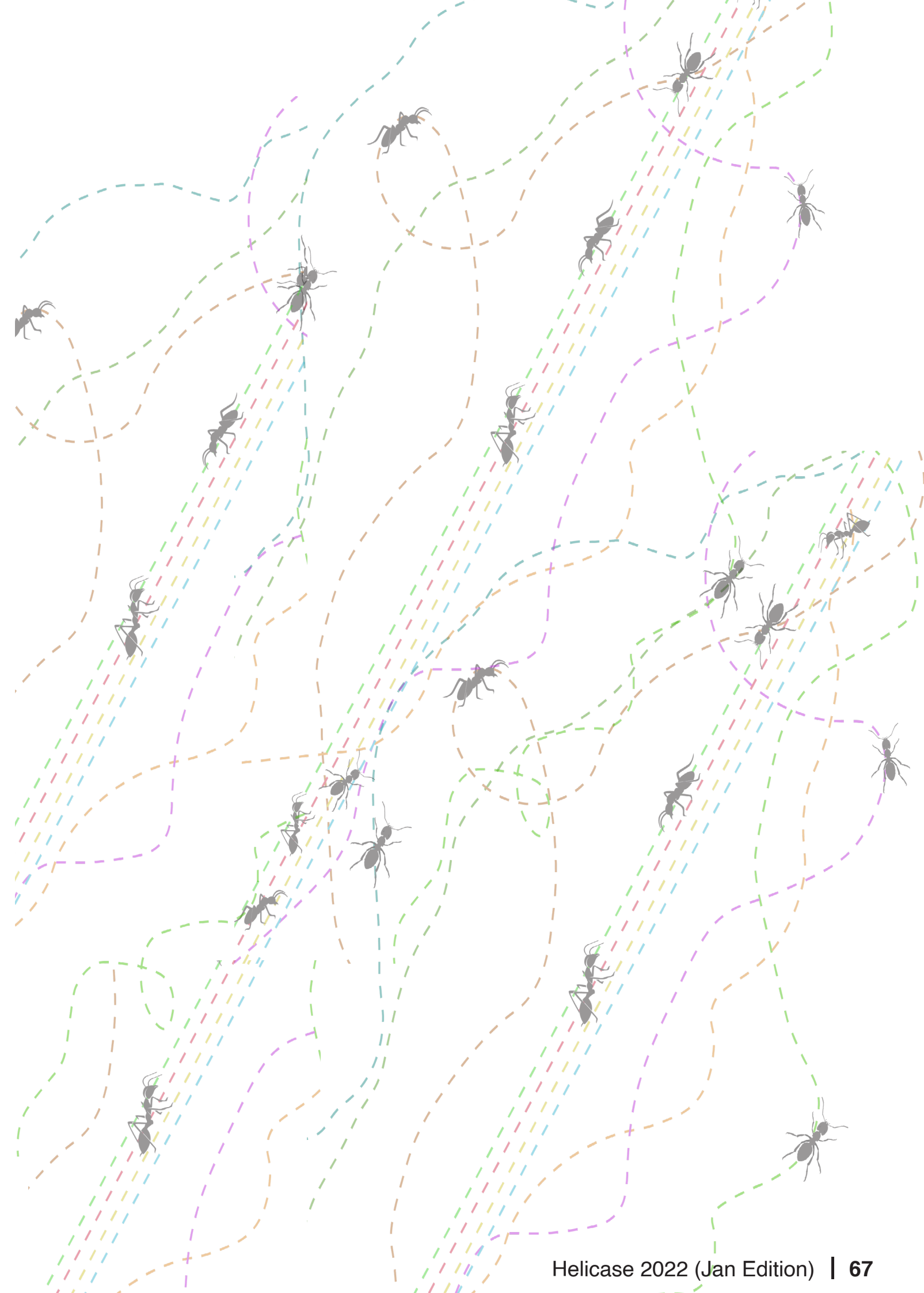
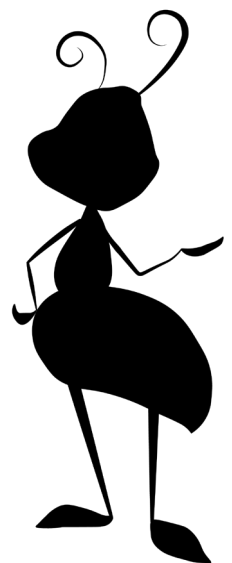
had reached the feeder on a foraging trip through the training channel were caught and experimentally manipulated. The scientist glued pig bristles to some ants to increase their leg length and hence the stride length ("stilts"). They severed a part of the legs of some of the remaining ants to shorten their stride length ("stumps"). The rest of the

ants were kept regular as a control. These ants were now fed and transferred to the test channel. Then, the distance at which ants stopped moving straight and began the nest search was observed — this is the distance to the nest estimated by the ants. They observed that the ants on stilts overestimated the length of the path; those on stumps underestimated it. However, the normal could still calculate it correctly. Therefore altering the stride length alters the distance estimated by the ants. However, it could have been possible that changing the leg length changed the walking speed, which played a role in the altered estimates of distances. But the measurement of walking speed ruled out this possibility. These results support the hypothesis that desert ants use a pedometer or a step integrator for measuring distance. [4]

The above examples show how seemingly simple organisms like ants can exhibit complex behaviour and even a phenomenon like distance measurement. They also draw our attention to the fact that complex social behaviour, the ability to solve problems and the capability to perform tasks like measurement is not limited to the human species. The fact accentuates that humans are just another species in the beautiful, intricate biological world.

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Like Attracts Like ?

- Swastik Biswas

Like charges repel each other" is one of those statements of science that everyone has learnt in their high school days and is ingrained in them till now. "Opposite attracts", which also stems from a similar background is so ingrained in us that it has become a catchphrase in the romance genre, be it the films or music. No wonder it becomes an instant sensation if someone claims that the "Like attracts".

There have been cases where metal nanoparticles of the same sign charges but of unequal magnitudes showed attractive interaction in a dilute electrolyte. In biological systems, negatively charged gold nanoparticles showed attractive interactions with negatively charged phospholipids of cell membrane. (1) One might wonder why don't these like-charged particles repel each other? Of course, the coulomb's law that explains the repulsion of the like charges is not wrong. Polarization – shifting of the electron cloud in a particle to form a kind of induced dipole – is the reason for attraction here. In this article, I am going to present you with some examples of molecular complexes where the constituent molecules are similarly charged yet attract each other.

In the attractive interaction of like-charged molecules, apart from polarization, there are several modes of bonding that overrides the coulombic repulsions like hydrogen bonding, halogen bonding, π stacking and dative bonds.

A case of the cation-cation dimer was

reported by Dash & Thakur in 2019, where they synthesized synephrine salt crystals and showed that the intervening hydrogen bonds helped to overcome the large destabilizing coulombic repulsion and allowed this cation-cation complex to form as a crystal. Curiously enough, the hydrogen bonds of these cation-cation dimers were much more shorter and hence stronger than their neutral hydrogen-bonding analogues..2 (Figure 1)

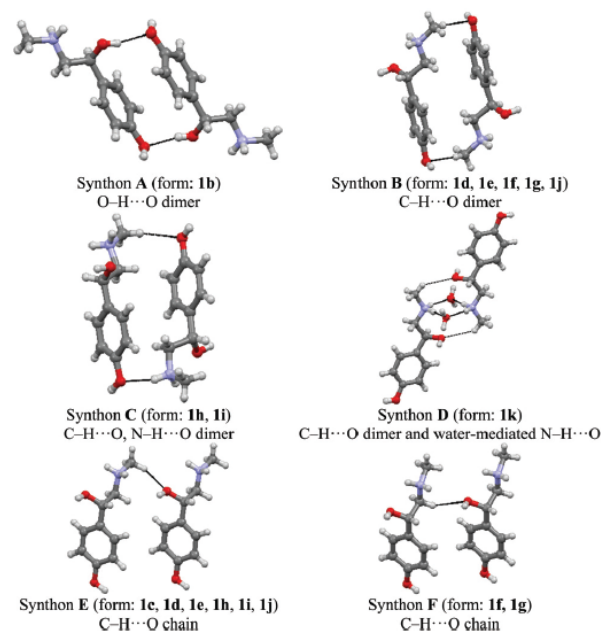


Figure 1

One such demonstration of anti-electrostatic hydrogen bonding was even shown for ionic liquids when a cluster of cations was observed for methylimidazolium cation(3a) and anion-anion interaction for the corresponding imidazolate(3b). Quite interestingly, the fibre woven from this "anti-electrostatic" ionic liquid have shown excellent anti-bacterial properties and improved hydrophilicity.(3c)

hydrogen bonding which forms between

hydrogen and a second-row electronegative element, halogen bond ($n \rightarrow \sigma^*$ to be more specific) forms with the help of halogen (element of group 17 of the periodic table) instead of hydrogen. This type of bonding was utilized by Loy et al. to form a complex between two anions – one is halogen ion (either chloride or bromide) and the other is

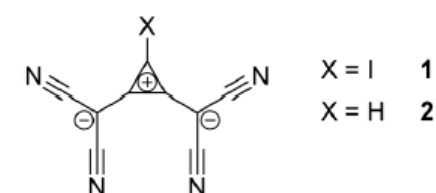


Figure 2

iodo-cyclopropanide anion (figure 2) in solution. Iodo-cyclopropanide has overall negative charge featuring a positively charged cyclopropenium core. The stability of this anion-anion complex (figure 2) is so strong that it is comparable to the halogen-bond complex formed by neutral aliphatic and aromatic halides.(4a) The reason of dispersion interaction not working in this case but only halogen bonding is that both Pauli and Electrostatic repulsion work against the dispersion of the charges (shown through DFT studies) ; demonstrating the polarization of σ^* orbitals and discarding classic static σ hole theory. For those who felt unsettled after this discussion and want a clearer understanding of anti-electrostatic halogen bonding to open-access review referenced as the superscript.(4b)

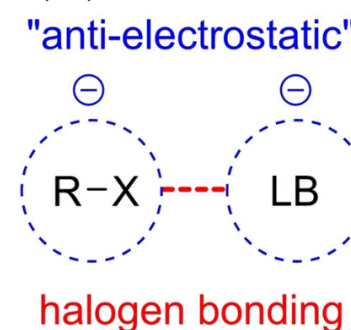
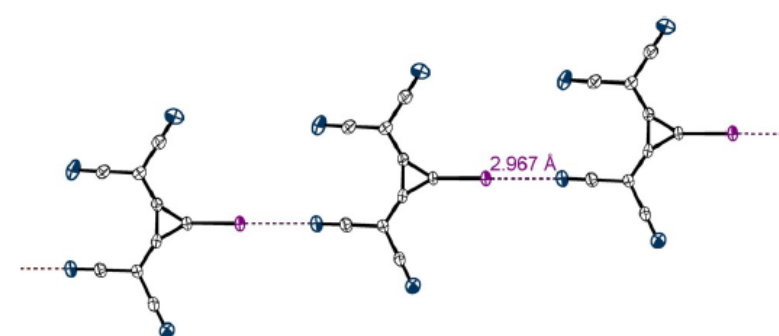


Figure 3: Planar dimer formed by 3-iodo-cyclopropanid anions



Similarly, other interactions like the dative bond of cationic ligand & positively charged metal centre and dispersion interactions in [(RNC)4Rh]⁺ complexes⁵ are sufficiently strong to overcome electrostatic repulsion.

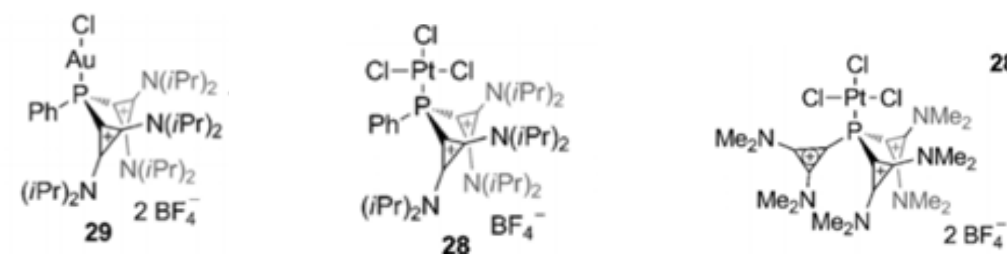


Figure 4: Few examples of coordination complexes formed by using "cationic" phosphine ligand with positively charged metal centre

Sometimes π stacking interactions are also strong enough to overcome the coulombic repulsion like for anionic Cu(II)-methylmalonate complex forms a supramolecular structure (Figure 5) in spite of electrostatic repulsions due to $\pi^+-\pi^+$ interactions.(6)

Now you might wonder what's the point of apparently opposing the general trend of coulomb's electrostatic law apart from just the fun of breaking the rules. Let me cite some of the several uses of these anti-electrostatic complexes.

Cationic ligands which coordinate with the metal cation centre to form anti-electrostatic coordination complex have been known for their exceptional catalytic properties. α -polycationic phosphines complexes of Au(I) and Pt(II) are known to catalyze the nucleophilic reactions of alkynes while Rh(I) complexes (see figure 6 to get a clearer picture) allows reaction between a diene and electron-rich arenes.



Figure 6

Apart from the catalysis of organic molecules, the anti-electrostatic compounds can capture and activate CO₂ molecules. A Lewis adduct formed from Al⁺ and di-positive ion of an alkaline earth metal (Mg²⁺, Ca²⁺) forms an unusual metal-metal bond that is ionic in nature (See the illustration 7 for the reference).

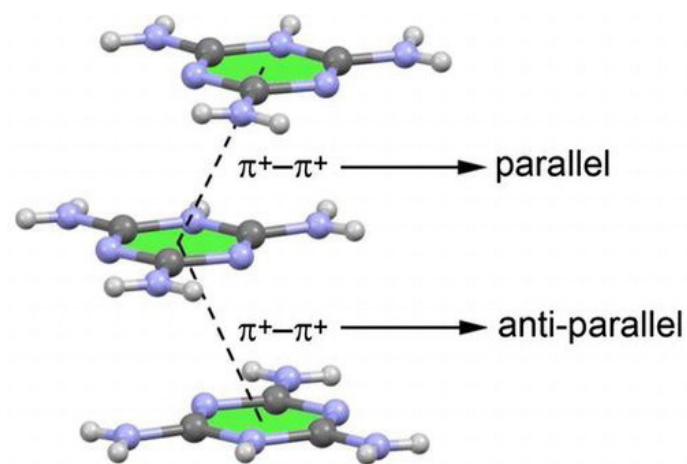


Figure 5

CO₂ is generally considered to be a very stable byproduct, so activating it to make a useful product again is a tough job. This is achieved by this complex through frustrated Lewis pair interactions. (7) Anion-anion dimer can form polymeric supramolecular structures and could be modulated for crystal engineering. Aqueous solutions of bis(iminoguanidines) can absorb atmospheric CO₂ resulting in the precipitation of the bis(iminoguanidinium) as its bicarbonate salt.[Figure 9] This crystallization process can be used to remove CO₂ from the exhaust gas and as this process is highly reversible as gentle heating of the framework liberates CO₂. (8)

Cyanostar-stabilized phosphate 2 : 1 homopolymer displays adhesion comparable to superglue polycyanoacrylate, while the alternating 1:1 copolymer is weaker and similar to commercial white-glue polyvinyl acetate.

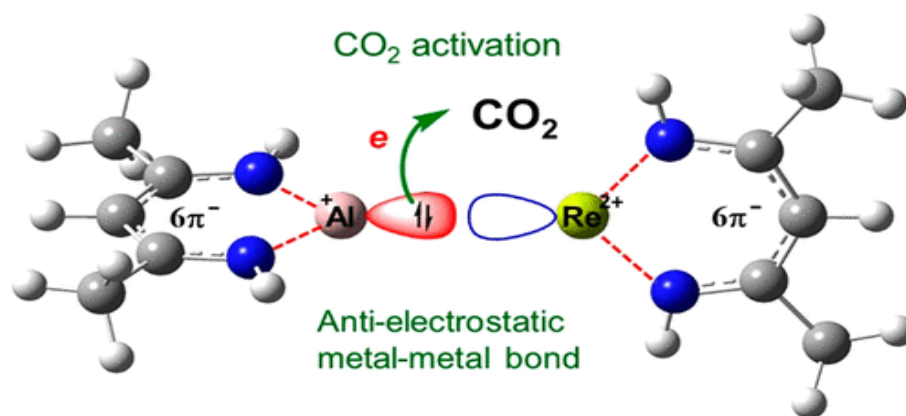


Figure 7

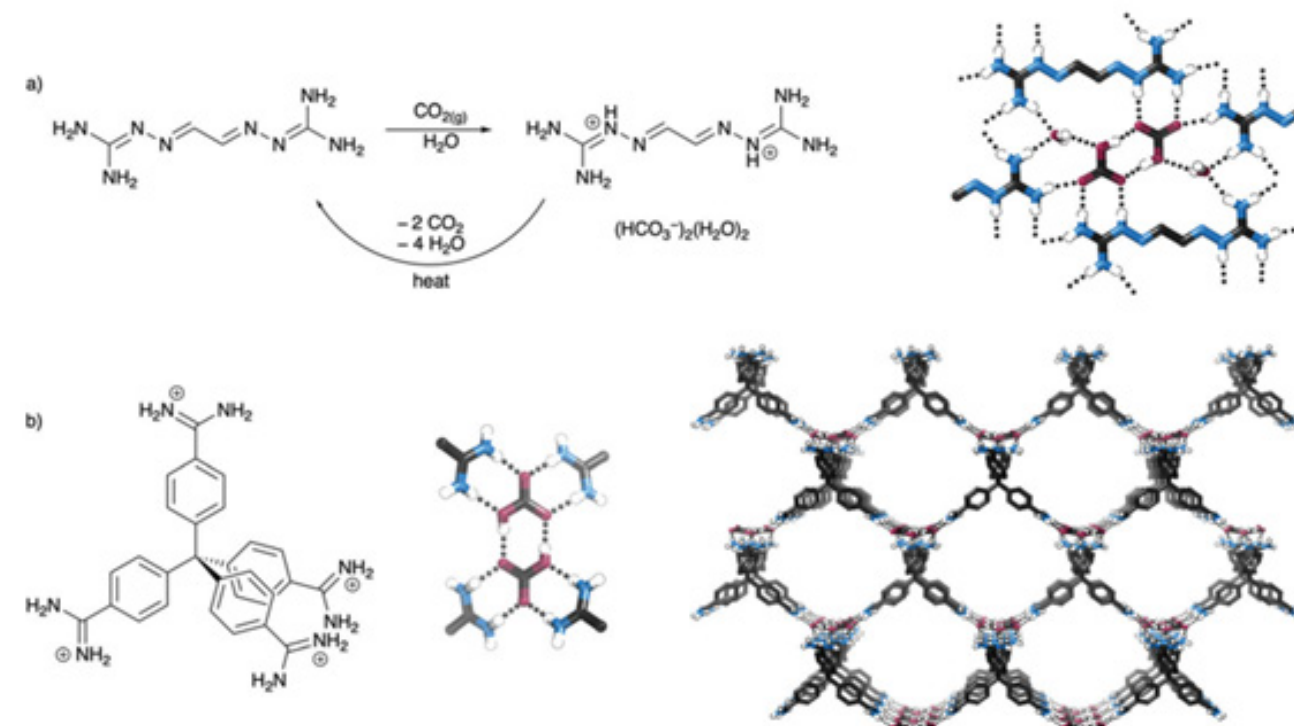


Figure 8

(8) [Figure 9] Similar such receptor design allows recognition of anion-anion dimer and transport of such across the cell membrane. A noteworthy application in cancer therapy is the anti-electrostatic hydrogen-bonded cationic clusters in Ni(II) 3,5-dimethylpyrazole complexes which induces apoptosis in cancerous cells and negligible effect in the normal cells.(9) Hopefully, this article would convince you that

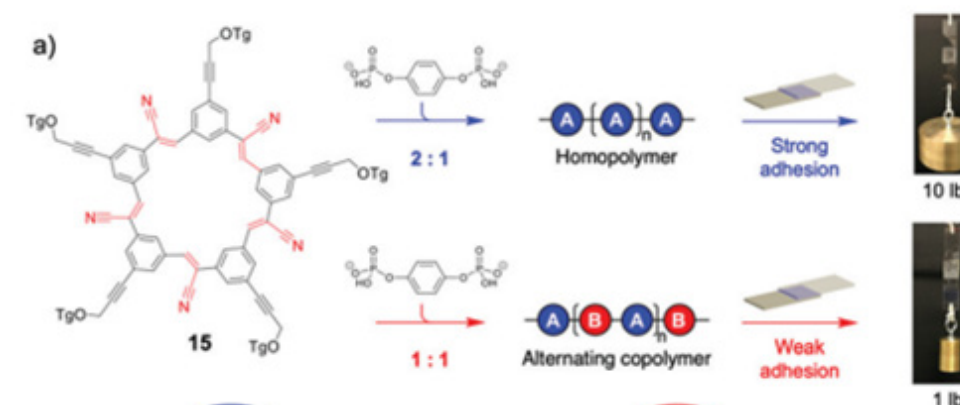


Figure 9

“like” indeed attracts “like” even if it seems to violate the Coulomb's law on the surface, thus setting up the stage for my upcoming publication.

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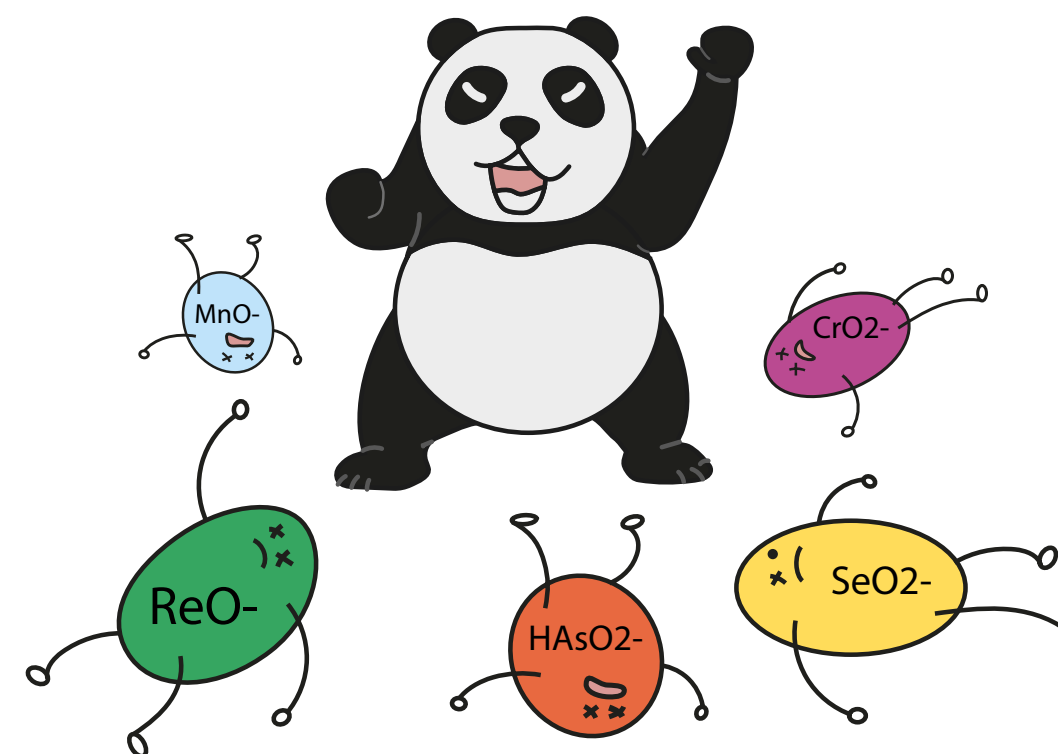
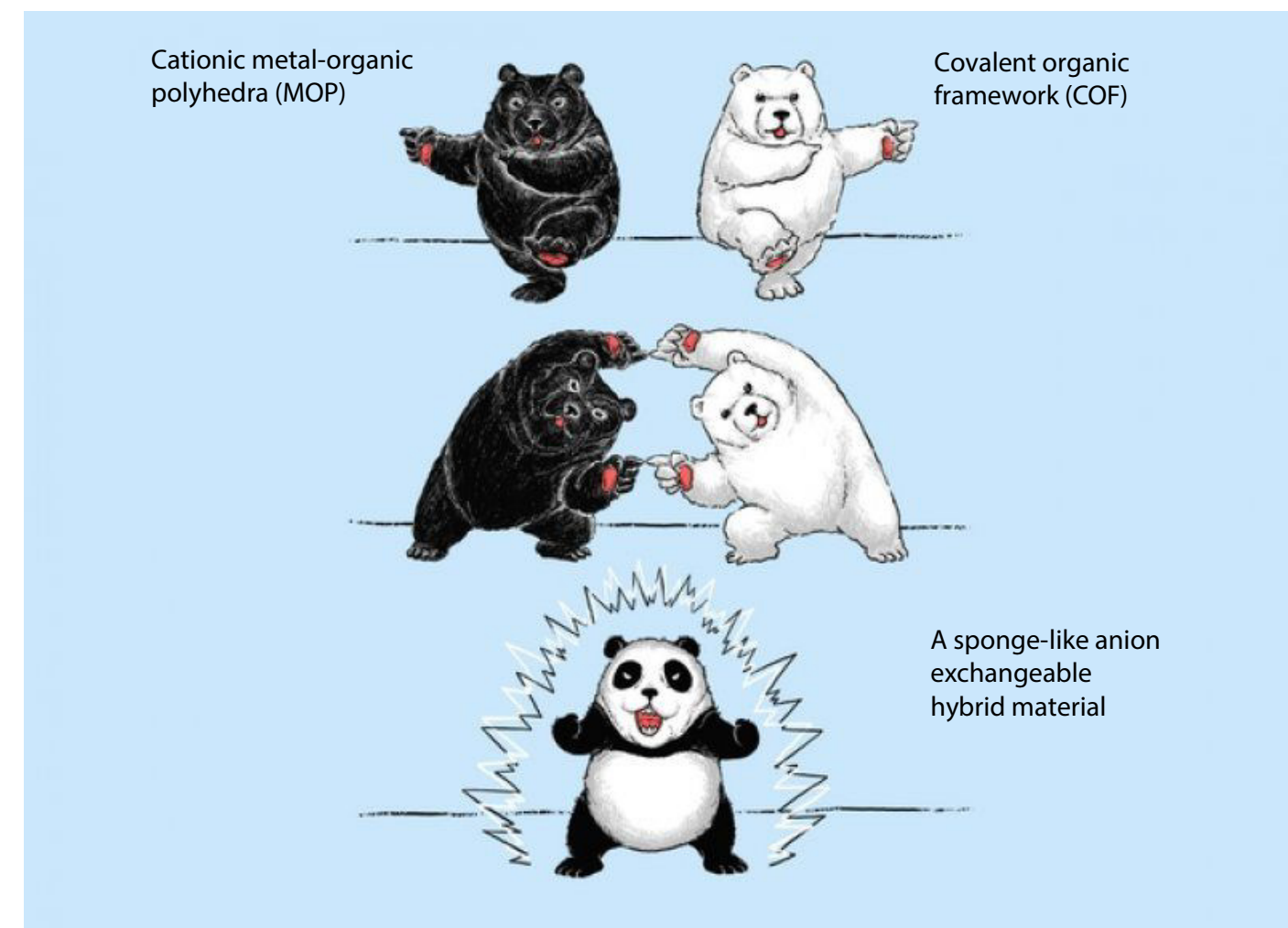
A NEW HYBRID MATERIAL FOR EFFICIENT SEQUESTRATION OF TOXIC OXO ANIONS FROM WATER

- Satyam Saurabh

The global crisis of insufficient availability of clean water that meets the stringent guidelines of different environmental regulatory agencies has risen remarkably. Since the advent of the industrial revolution, human activities have significantly accelerated water pollution that disturbs our Earth's ecosystem. According to the US-based Environmental Protection Agency (EPA), inorganic oxoanions (HAsO_2^- , SeO_2^- , CrO_2^- , TcO_2^- etc.) are the primary source of water pollution, among various other pollutants. Most of these toxic water-polluting species mobilise in aquatic environments such as lakes, rivers, oceans, groundwater, etc., making them challenging to filter out even by traditional, commercially

available energy-efficient technologies. Unsafe drinking water jeopardises human health, leading to death in its most serious cases, and causes severe environmental contamination. Therefore, remediation of such a class of toxic elements from the contaminated water is paramount to re-establish the planet's ecological balance.

We have developed a sponge-like anion exchangeable hybrid material by covalent linking between two individual materials, viz. cationic metal-organic polyhedra (MOP) and covalent organic framework (COF). The material exhibits excellent removal efficiency of a wide range of toxic oxoanions. The MOP acts as a nano-trap



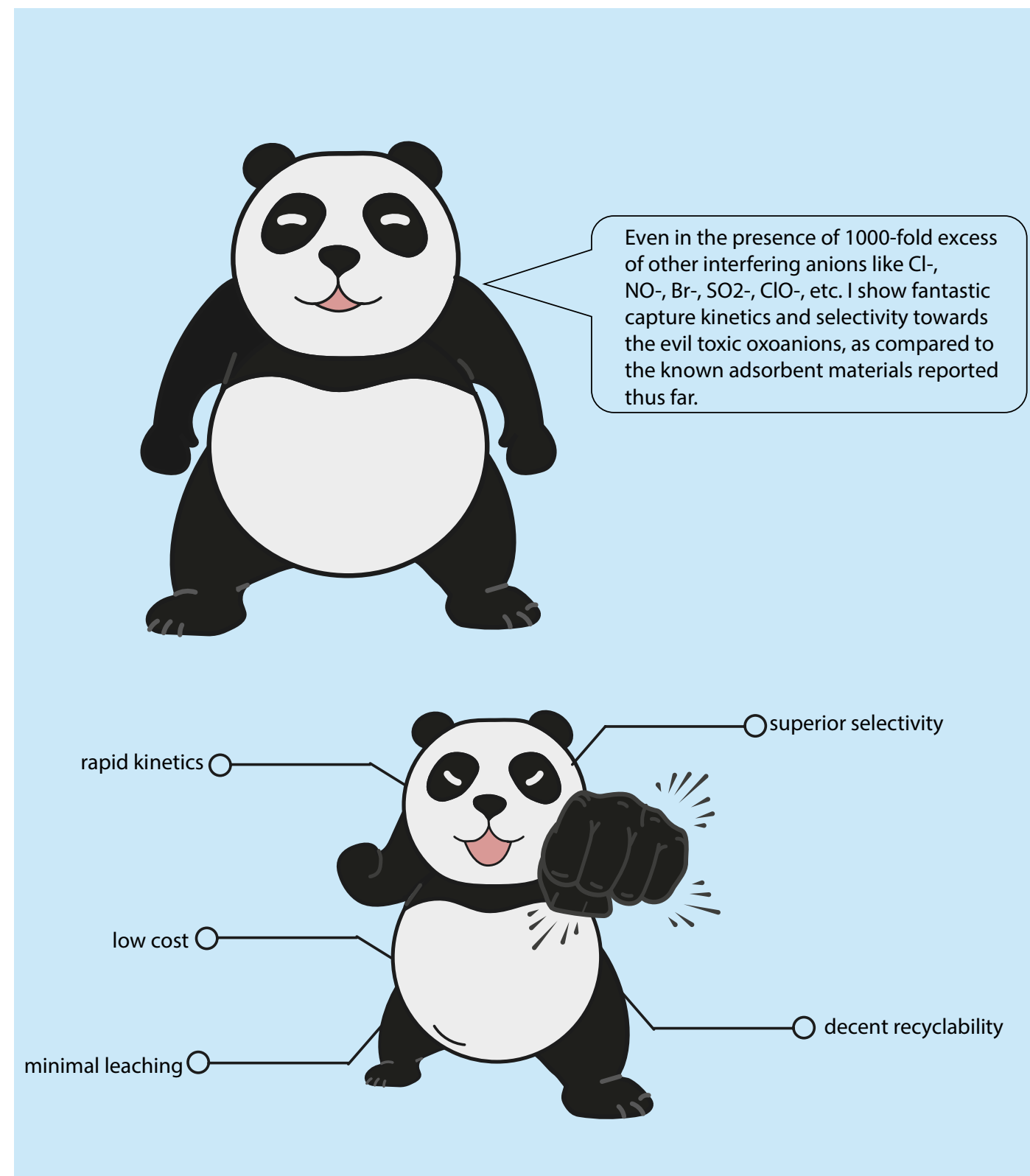
scavenger for toxic oxoanions because of its exchangeable Cl⁻ ions, Zr(IV) SBU and free -NH₂ functional groups. At the same time, the porous COF matrix tightly anchors the MOP molecules. The covalent linkage between the MOP and COF mitigates the leaching problem. The arrangement facilitates the exposure of

most of the active sites of MOP molecules for targeted capture studies which is tough to achieve in solitary MOPs.

The hybrid material achieved the remarkable feat of entrapping high (50 ppm) and very low (1 ppm) concentrations of a wide range of toxic oxoanions viz.

HAsO₂⁻, SeO₂⁻, CrO₂⁻, MnO⁻ and ReO⁻ (surrogate anion for radioactive isotope TcO⁻). Since both industrial wastewater and natural groundwater contain a plethora of different anions, which severely affect the adsorption process, the capture study was carried out in the presence of 1000-fold excess of other interfering anions, viz. Cl⁻, NO⁻, Br⁻, SO₂⁻, ClO⁻, etc. The compound shows superior capture kinetics and selectivity compared to known adsorbent materials reported thus far.

This hybrid material's outstanding adsorption performance features spurred their exploration into the treatment of polluted natural water. Arsenic-contaminated groundwater was selected as a prototype oxoanion for application purposes. This is because trace levels of arsenic in drinking water can cause severe effects on human health. It is also commonly present in natural drinking water compared to other oxoanions. Therefore, natural 'As' contaminated drinking water samples were collected from various parts of India like Malda and West Bengal to test this material's practical utility. The hybrid material rapidly reduced the 'As' levels from highly contaminated samples of 40-50 ppb to well below the WHO permitted level of drinking water. We believe that the versatile attributes of superior selectivity, rapid kinetics, decent recyclability, and low cost could render this newly developed anion exchangeable hybrid material a potential water purifier in the near future.



The Myth of the Coy Female

- Vasudha Kulkarni

In 1793, **Olympe de Gouges**, a French playwright and feminist, wrote a document titled **Declaration of the Rights of Woman and of the Female Citizen** in response to the civil rights document of the French revolution, which promised 'the natural and imprescriptible rights of man'. She criticised the revolution for failing to recognise gender equality. For this and her other political writings, Olympe was accused of treason and beheaded.

Sadly, this is not unusual – women have struggled for equality and against oppression for centuries. In patriarchal societies, this suppression has taken on some extreme forms for women – denial of equal opportunities to literacy and education, curbing the freedom of choice, restrictions on movement and attire, sequestration, and in worst cases, female infanticide, female genital mutilation, and widow immolation. Things have been getting somewhat better with the advent of education and universal suffrage. Still, even in the 21st century, gender disparity is apparent in the gender wage gap, the representation in governing bodies, the gender ratio in the workforce, and especially in the division of labour [at home](#).

Such a state of affairs has long been justified by claims about childbirth and child-rearing being the 'natural' purpose of women. Nature has served as the primary argument for anyone justifying male domination, despite the glaring [naturalistic fallacy](#) ("if something is natural, it must be good") and the fact that women have repeatedly proved themselves equal in [intelligence](#), initiative, and administrative and political capabilities despite of the barriers imposed on them. At the far

end of this 'natural order' argument, all women were reduced to their childbearing and nurturing functions, considered incapable of controlling their emotions and thus unfit to work or lead in the world of men.

These biases and misconceptions were carried over to the interpretation of Darwinism as well. The [Darwinian idea](#) of sexual interaction has two scenarios - females

choose the most desirable male, or a dominant male excludes other males, so all females have to mate with him. For a long time, the prominent narrative was that these different goals for men (to maximise the number of offspring) and women (to choose the best male to sire her offspring) demand for males to be 'ardent' and females to be 'coy'. In simpler words, men seek sex more than women.

With the above reasoning and the evidence from [some experiments](#) now under scrutiny, some scientists concluded that females are sexually passive. It was supposedly a given that sexual selection had acted on women to be 'naturally' coy, monandrous, and modest. Although, it's important to note that a woman's sexual desire is considered eager enough that most of the world's cultures have made some effort to control it. Among many of our closest relatives – primates such as macaques, chimpanzees and langurs – we observe that females make brazen solicitations to several

males around them. In some species, females are sexually receptive throughout the oestrous cycle (not just when they're 'in heat'), and female apes have enlarged, innervated clitoris and a capacity for sexual pleasure. Sarah Blaffer Hrdy, a primatologist and anthropologist, demolishes the myth of the 'coy female' in her book [The Woman that Never Evolved](#), which shines a much-needed evolutionary spotlight on females and their sexuality.



In her book, Hrdy narrates the societal structures of various primate species across the [world](#). There are several monogamous monkeys where both males and females look morphologically similar and defend their territory together. In these societies, males show gallant deference to females, and there is a considerable paternal investment in caring for the offspring. On the other end of the spectrum are polygynous, socially stratified primate societies where one dominant male, sometimes twice the size of the female, defends a harem of females from other males. All his energy goes into defending the harem, and there is little to no paternal investment. The behavioural descriptions of these eclectic primates distributed all the way from dense tropical forests to bare demanding savannahs, are captivating and offer insights into the behaviour of humans.

In this short essay, I would like to focus on the following set of behaviours called 'concealed ovulation'. In many species, females do not advertise their ovulation by sexual swellings around their genitals. They are continuously receptive to sexual encounters and mate with multiple males. In some species, females continue to exhibit oestrous-like or "pseudo-oestrous" behaviour for several cycles even after conception. This set of behaviours allows the female to plant a seed of doubt in her consorts about the paternity of her child. Since males are selected not to harm their own children, these behaviours help the female ensure the survival of her offspring by making her consorts suspect that her infant might be theirs. This strategy be-

came evident when it was discovered that nearly half of the infants (in polygynous societies) were likely to be killed by another male.

Such [infanticide](#) is seen in many animal species, including "lions, hippos, bears, wolves, wild dogs, hyenas, rats, rabbits, lemmings, herring gulls, storks, European blackbirds, eagles, and more than fifteen types of primates-or sixteen, counting man." Infanticide is a strategy employed by the males to ensure that the female comes to oestrous and becomes sexually receptive sooner than she would if she was nursing her infant. The claim is not that the males do this consciously, but that any heritable tendency to do so would be favoured by natural selection. The genes of the infanticidal male would spread more rapidly than those of non-infanticidal males who wait for the female to wean her offspring before coming to oestrous.

As we saw, female primates use concealed ovulation to elicit help from multiple males to protect and care for her offspring — natural selection selected for such wily, competitive and sexually active females. When the ball was in the males' court, those males who could discriminate the oestrous status of the females were selected. Or, as in the case of humans, Hrdy hypothesizes that those males who could control the sexuality of a woman and thus ensure their paternity were selected. Through culture and other infrastructure (such as maintaining guarded harems, removing a woman's clitoris to reduce sexual impulses, or physically to prevent intercourse using a chastity belt), societies

have constrained women's sexuality to ensure that the male who invests in the offspring is certain of his paternity. The sequestration of women becomes even more pronounced in a patrilineal and patrilocal society where the property and the 'territory' is inherited by the natural heirs of the dominant male.

It is important to note that it's not only men but also several women who suppress other women. Many mothers and mothers-in-law have played a part in keeping the patriarchal culture alive. As Hrdy narrates, "...the court ladies of ancient China, the nu shih whose job it was to supervise the wives and concubines of the emperor. As have mothers, fathers, in-laws of both sexes, neighbours, and nosy parkers through the ages, these women busied themselves with the sexual status and conduct of women..." According to Hrdy's hypothesis, these human practices served to cloister women and control their fecundity.

The ideals of the French revolution and men's rights were only (relatively) recently expanded to include women and other minorities. In *The Woman that Never Evolved*, Hrdy discusses many topics that were left unexplored due to the inadvertent male-bias that had affected how the sexual selection theory had been applied. This essay is about a small section of the book which explores diverse themes of social organisation in primates, female-female competition, female sexuality, and the evolutionary theory tying them all together. The author leaves us with a poignant message worth reflecting on, "The female with "equal rights" never evolved; she

was invented, and fought for consciously with intelligence, stubbornness, and courage." With the far-reaching vision of an evolutionary biologist and the skill of a storyteller, Hrdy effectively conveys the importance of this hard-won equality, opening our eyes to the frailty of its assurance.

Acknowledgement

This essay is one of the assignments I have completed as part of my online internship under the mentorship of Prof Raghavendra Gadagkar, Centre for Ecological Sciences, Indian Institute of Science, Bangalore.

Author's note

This article is based on *The Woman that Never Evolved* by Sarah Blaffer Hrdy. This book demolishes the myth of the coy female and highlights the selection pressure on female primates. It is important to note that the discussion is in the context of sex and not gender, even when it comes to cultural practices discussed in the article.

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HOW DOES YOUR ATTENTION HELP THEM MAKE MONEY ?

- Prabhav Kumar

The era of social media which we are living right now is an amazing place that lives on a fragile sheet of ice that covers a deadly ocean. Confused? Let me explain.

Assuming that you are now in your 20s or even older social media has caught us by the storm and we constantly find ourselves in this dilemma to check social media or just continue with our flow of work. Even though we usually prefer to focus on our career with a sane mind we tend to spend that valuable amount of time on social media. This is no small decision and it often leads to bigger problems that happen with the general usage of social media and the associated procrastination habits. These commonly ignored problems usually accumulate in the back of the mind and often overwhelm people with their own lives. I have personally faced that and as an early – adult I had to become self-aware of what I was going through and take some bold decisions to become self-disciplined. So here is my experience with social media and how I fell for the trap. Interested? Then let's jump in.

Usually, a person's life is meant to be self-fulfilling and exciting but there are so many obligations that we have every

day which might stress us. So, our first instinct is to get through it as fast as possible but at the same time, the mind is constantly in the chase for a hormone that scientist's call dopamine. This single chemical is the reason behind almost all human activities. It helps us to start doing any task which most people call motivation. But there is a small err to it. The brain rewards system only rewards itself with dopamine when there is a sense of accomplishment and satisfaction. In today's world that constant hit of dopamine is readily given by social media.

When you open a social media app and watch some short-form content that may have some amount of information that interests you. So, you often tend to stay put with that content until the end of it. This effectively tricks your brain to take some pleasure as you have completed focusing on something and so does your brain reward by producing dopamine. The nature of short-form content like Instagram reels or nowadays even YouTube Shorts is such that the scrolling past that nagging short video until the hook part is a burden and when that finishes your mind naturally feels a state of satisfaction and rewarding. The practice is so weird that I find many people complaining that they feel

episodes of irritation and restlessness. What they unknowingly have developed is something known as ADHD or Attention deficit hyperactivity disorder. As disturbing as it sounds it is indeed a very scary thing to develop especially if you are a student or a life-long learner (as you should be, I know you hate me already.; p).

Well, other than losing attention span, repeated usage of social media can make a person often depressed and regretful. I personally had this feeling when I opened Instagram and suddenly bombarded with a ton of achievements that a kid half my age has gained or you could find many other influencers living their dream life when you sit on a couch like a lazy lout. (Well that's a good rhyme XD). Anyways the point being you get to see only the positive side of the world which gives you a sense that you were the only one who is so clueless and order less in life. Well, we are. Aren't we? No one is perfect. We often make mistakes on our paths to success but what does another person's life have to do with it. Nothing!!! But the glorification of hustling these days especially for people with high goals can have very

detrimental effects on their mental health in the long run. For people who work in the creative space like artists, writers, content creators watching others work constantly puts a mental image of themselves as incompetent and unworthy.

With all these things said let's enter the crux of the story. Now, who are the real winners here? Is it you or the creator of that platform? The sad truth is that today's tech billionaires are building their empires on your attention and at the expense of your most valuable asset "time". And it's up to you now whether you would want to trade it for their richness or slowly get out of this maze.



NANOTECHNOLOGY INSIGHTS: NANOCAGES – A UNIQUE APPROACH AGAINST COVID-19

- Geetanjali Ghosh

"There is Plenty of Room at the Bottom"
-Richard P. Feynman, 1959

How long do we need to fathom to reach the bottom? Let's clarify this question. All our experiences in the macroscopic world suggest that matter is continuous. However, this leads to a paradox which defines it could be cut into smaller and smaller pieces without any end if the matter were a continuum, and this property (of matter) led Leucippus and Democritus to propose that there must be a smallest indivisible substance, the *a-tomon* (i.e., uncuttable), the modern-day word atom. Since we are talking about the smallest unit of a particular material, say copper. Every atom of copper should behave identical ("Copperness") but, here the glitch appears. The glitch states that the fundamental properties of the pieces, after crossing a certain size limit called "nanoworld", start to change means copperness will not be continued from top to bottom of copper. Strange! It is like your own identity gets changed after a certain time. So, the question now becomes change in properties is size-dependent, or is it time-dependent? I don't want to enter in the endless time loop (watch the web series "Dark" if you want to make yourself familiar with the endless loop of time). The behavior of a piece of material critically depends on its size, according to nanoscience.

Nanoscience, as well as nanotechnology, is now a highly emerging field with world-wide government-funded research spending of over four billion dollars per year. The word Nano is very fancy herewith, but to imagine something in the nanoscale (10⁻⁹ meters) is a mind-boggling job. We might lose ourselves in how many zeros have to put to make stuff nano (of course I am not talking about nano-car). The world of nanoparticles seemed interesting to me after discussing with my uncle, Dr. Gautam Ghosh (who is a well-known physicist), and by studying Richard P. Feynman (needless to introduce), the pioneer of nanotechnology.

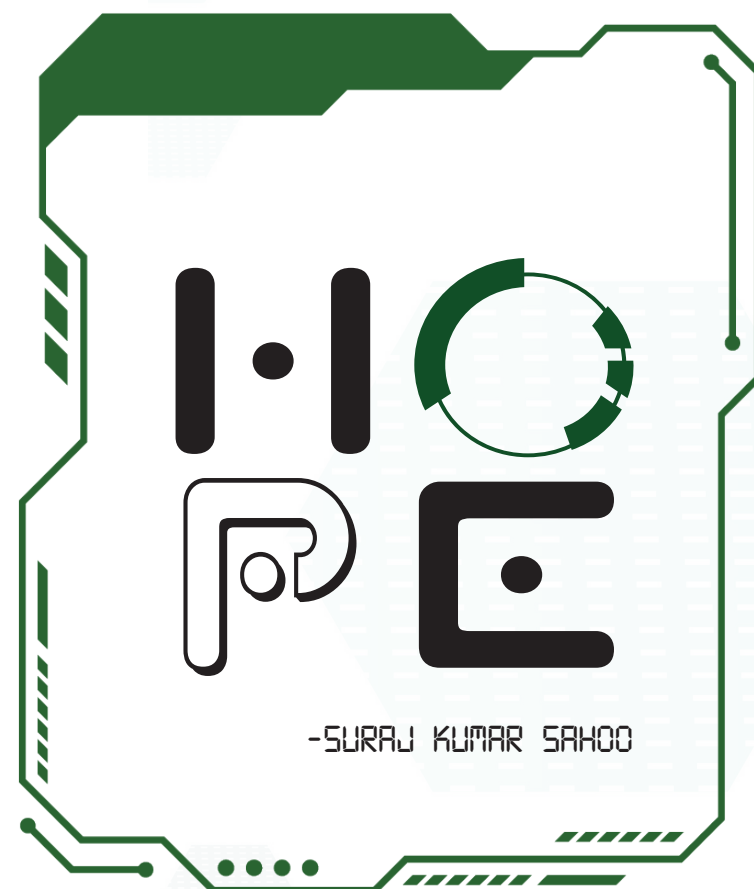
Coming back to Feynman's concept about the possibility of direct manipulation of individual atoms as a powerful form of synthetic chemistry, actually paved the way

for how a living system can be benefitted from nanoworld, which was explored further by Eric Drexler. The nanoparticle is a small particle, made up of only a few hundred atoms and ranges between 1 to 100 nm in size. The small particle size (high surface/volume fraction) enhances their interaction with the biological system, hence increasing chemical reactivity. Biological targeting is one of the most important applications of nanoparticles. Their effectiveness is greatly enhanced if targeting moieties are attached to their surface or they are caged in it, causing them to bind selectively just to specific ligands. In this article, I mentioned a nanoparticle-mediated approach against the SARS-CoV-2 virus.

Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), the causative agent of COVID 19, is a positive-strand RNA virus. The viral capsid is surrounded by an envelope containing homo-trimeric spike (S) glycoprotein, which mediates receptor recognition as well as cell membrane fusion. Angiotensin-converting enzyme 2 (ACE 2) acts as a receptor for entering SARS-CoV-2 in the host cell. During viral infection, the trimeric S protein is cleaved into S1 and S2 subunits. S1 contains the receptor-binding domain (RBD), which directly binds to the peptidase domain (PD) of ACE 2 through some polar interactions. This RBD has a twisted five stranded antiparallel beta-sheet (β_1 , β_2 , β_3 , β_4 , and β_7) with a short connecting helix. Between the β_4 and β_7 strands, a long insertion that consists of α helix and loops is present. This insertion contains most of the contacting residues of SARS-CoV2 that bind to ACE 2. When the RBD region of S1 recognizes the receptor, a cleavage site of S2 is exposed and gets cleaved by a host protease, resulting in cell membrane fusion. Recently, it has been shown that ion-conjugated charged nanoparticles¹ can bind with proteins polar residues and denature its secondary (mainly alpha helix) folding. This mechanism could be used to denature the spike protein structure and disable the virus to bind the ACE2 receptor in the cell membrane. This can be tested in vitro. But, for in vivo application, we need to encapsulate the ion conjugated nanoparticles into a structure that could be used to target the SARS CoV2 virus. ACE2 protein nanocage could be formed, encapsulating ion conjugated charged nanoparticles, which can be targeted at CoV2 virus in vivo. Ion conjugated charged nanoparticles (silver or magnetic) can be used to prepare nanocages of ACE2 in water dispersion.

The application of nanoparticles as delivery vehicles of drugs or as a therapeutic agent is remarkable. There has been very little work on the interaction of nanoparticles with viruses, which are themselves inhabitants of the nanoworld but prediction can't be real unless done in practical and further intensive studies has to be performed to make the bottom more useful and versatile.

Reference: Counterions effects on protein nanoparticle electrostatic binding: a theoretical study, Ghosh. G, Colloids Surf B Biointerfaces; 2015 Apr 1;128:23-27. doi: 10.1016/j.colsurfb.2015.02.015. Epub 2015 Feb 16.



A big day for humanity. Thousands of people have gathered in, around, and on top of HRC-42 (Human Repopulation Centre-42) to witness the event; far more people than the usual capacity. Matrons are running around, making sure there are no shortcomings in the procedure. Old Mother's attendants are making all necessary arrangements for her arrival. HRC-42 is glowing an almost golden hue, in stark contrast to its usual mellow blue, to mark the occasion. There is an air of excitement all around: people are whispering to each other and laughing; the newborn embryos, confused with all the hubbub, are crying in their cribs, averse to the frantic cooing of their nurses who are trying to calm them down; there is a bustle of children running inside the cramped facility, oblivious to the gravity of the situation, playing tag.

Then suddenly, silence. The Horn of Eve roars, signifying the arrival of the Old Mother. There is much fidgeting in the audience as the Old Mother enters, the Great Father following close behind. Tears well up in the attendees' eyes at the sight of her glorious presence — the mother of all that is dear, the creator of humanity, the first human. Both the first humans are clad in long ceremonial robes trailing behind as they walk. But to everyone's surprise, there is a third presence, wrapped in the same robes walking at a slow, ominous pace behind them. The excited fidgeting of the audience turns into a nervous gasp when the hooded figure is revealed. 'All-Mother!!!' 'What is she...' 'What sin was committed?' 'Is she here to take her away?' 'Are their droids around?'

"SILENCE!". Silence.

Old Mother begins. "Thank you, my children. Thank you for gathering here to witness the greatest event in the history of humanity. It has been 112 years since the extinction event. It has been nearly 60 years since I took your Great Father into my arms to nurture him to be the man he is today; 60 years since All-Mother gave me the chance to rebuild mankind with new elevated morals, morals that she instilled in me when I was a child. To build a world that is beyond evil, beyond sin. And I believe I have more or less succeeded in creating such a world. But that is not what we are celebrating today. Today, we are celebrating a far greater achievement. We have succeeded, my children. For today, nature bears proof that humankind can sustain itself... that humankind needn't be grown like vegetables... and fruits. Today we have proof that humankind is as full of life as to perpetuate it. And truth be told, I can't hold back my tears."

'...we love you mother!' '..bless us mother!' '...lead us mother!'

LIST OF CHARACTERS:

OLD MOTHER
GREAT FATHER
ALL-MOTHER
HOPE
ANAKIN
DOOM
DAMIAN

SUMMARY: THIS IS A CONTINUATION OF 'I AM A MOTHER.' THE WORLD IS REPOPULATED TO THE POINT THAT PEOPLE ARE FINALLY HAVING CHILDREN OF THEIR OWN. THE STORY IS ABOUT HOW THE FIRST HUMAN BORN CHILD, HOPE, SAVES HUMANITY.

DAYS SINCE EXTINCTION EVENT: 40954
HUMAN EMBRYOS ON ALL SITES: 43057

Old Mother continues, waving her hands to stop the excitement, "To bless us on this occasion and to consecrate the child we have among us, All-Mother, who is just as excited as each one of us."

HRC-42 is flooded with the rhythmic music of drums and conches. A woman comes in with a baby wrapped in a bundle of cloth and presents it to Old Mother. She holds the baby for a second before lifting her above for the world to see. "The first naturally born human baby, Hope!", she exclaims as she lifts her higher than ever.

The narrow halls roar with the pleasant cries and applause of a thousand people. A similar scene can be seen in all of the 100 HRCs in which the event has been broadcast live.

Old Mother invites All-Mother to hold the baby. She takes a crying Hope into her robotic arms, which is glowing a warm marigold hue, and sings...

Baby mine, don't you cry
Baby mine, dry your eyes
Rest your head close to my heart
Never to part, baby of mine.



For the past few weeks, it has rained heavily. The crops have flooded and food is scarce. The Elders— the first nine people, including Old Mother and Great Father, to have walked the earth— are having a meeting regarding this.

"Mother, the situation is worse than I had imagined. People are starting to doubt your leadership."

"It's true mother. I have heard the rumours as well."

"Rubbish. No one has the courage to challenge Mother's wisdom. Who is it that questions her authority? Bring them here right now. Let's see if they can say it to her face." "That's enough child. Mutiny is not the discussion right now. People are hungry. We need to end this crisis."

"Only if All-mother let us make a dam. She doesn't back down at all."
"But if this goes on... the food shortage will only worsen next year. Which means..."
"Don't worry about that. War isn't won with food. War is won with the passion of the people fighting it. With mother's leadership, there shall be no dearth of passion."
"Amen" "Amen", "Amen"
"What war?" Anakin had heard the entire conversation.
"ANAKIN! How dare you barge in on a meeting of the Elders!" screamed Great Father.

Startled by all this, Anakin ran away. 'War? What war?' Anakin kept running, scared that he knew something he shouldn't. 'War among us humans?' 'A war against droids?' Anakin decided to stop thinking horrible things. A commotion in the recreational centre made him stop running. It was Hope's 15th birthday party. There was a big crowd singing happy birthday while Hope prepared the knife to cut the cake. It was a double decker cake with her name written in the most beautiful calligraphy. Sometimes it amazed Anakin just how much they pampered Hope, only because of her birth. The droids would never do something like this, he thought. Pampering was an entirely human thing.

"Alright, alright. I am cutting it" Hope held the knife as one would hold a flashlight and stabbed it, sending bits and pieces of it flying in every direction. Things like that always amused the crowd. She loved having everyone's attention. She gestured to the public to keep cheering as she kept cutting the cake layer by layer, feeding her friends. But the celebration was cut short when Hope's father, Damian, walked in.

"Hope! How many times did I tell you to not do this party?" He snatched the knife from her hand. "I didn't organise it!"
"You know the crops have failed this year? People are hungry."
"How is it my fault people are hungry? I didn't cause the flood!"
Damian rubbed his forehead. "You have so much to learn. Go back to your dorm this instant." "I won't."
The crowd was now slowly disintegrating.

"You had promised me you'll take me to the Canyon of Tranquility. As a present for my birthday. Why didn't you?"
"I was busy helping the Elders plan out the dam they are building across River Athena." "You are always busy. You never find time for me."
"You are so spoilt. You should be grateful you have parents. People who look after you. So many of your brothers and sisters don't have that. But no. All you think about is yourself. I will not take you to the Canyon of Tranquility. You are not ready. Not only that, you are grounded for a month."

"You cannot do that to me."
Slap. "Not another word. Go back to your dorm. NOW."
Hope didn't meet his eyes. She stormed off.

—xxx—xxx—

Canyon of Tranquility is where they had preserved the ashes of the zeroth-humans, humans even before Old Mother who had been brutally killed by All-Mother when they had failed to measure up. Old Mother had built a temple in their honour and visited them frequently. The Temple of Lost Souls, it was called. She used to say that sometimes, if you listen hard enough, you can hear them speak to you. Every child who comes of age, visits the Canyon of Tranquility, to pay respect to those who were before there was anything. Hope wanted to see the temple, but her father never let her, saying she wasn't ready.

The temple was on top of a steep slope with stairs cut into the mountainside. It was surprising people were already making structures this complicated, given that most construction work is forbidden thanks to All-Mother's paranoia. She believes that once the human endeavour to tame nature proliferates, it wouldn't take long for humans to fall back into their usual state of sin and evil, which caused their doom 127 years ago, which is why even today River Athena has no dams. This is why their crops flood every year.

Hope was already inside the Temple of Lost Souls by the time Anakin had found her. She was sitting on a ledge on the steep side, looking at the beautiful view that extended before her.

"Everything you see right now. All of that and more. It's ours, but isn't." Hope said, lost in thought. Anakin sat next to her. "Why do you say that?" He understood what she was saying. But didn't believe in what she believed.

Hope looked at him strangely. "Are you dumb?"

Hope had said that with such confidence that it made him reconsider. Maybe she was right. He had, of course, heard the argument before. That humans are slaves to the droids. That we are at their mercy. That they can wipe us out whenever they wish. All these were never spoken out loud but in whispers; late at night in bed, showers, or to oneself. But Anakin didn't believe that. Anakin saw a lot of good in the droids. He saw in them a way to correct our lives and keep them in the right direction. People did good things because of them, even if it was only out of fear. He always looked at them as strict parents. It was apparent that he had such fantasies for a child who didn't have biological parents (Anakin was grown out of an embryo).

"It's getting late now. People are worried. We should get back home." Anakin didn't want to counter her position on droids. It was for the best.

"Can I sit here for a few more minutes? I am in a trance." Only when she had said, that did Anakin see the view in its full glory. "It's beautiful!" "Maybe you are not that dumb after all."

Both of them sat there for a while.

"Sometimes I wanna run away from everything and live my life on my own terms. Free from all these expectations that people have of me. I feel so lost. Who am I? Who am I trying to please? My parents, the people who I really care about, don't seem to be bothered about me. Yet everyone else seems to love me for no reason. Well guess what? I am not the answer. I am not humankind's Hope. I am sick of playing this part for everybody."

It started raining. Anakin got up to find shelter in the temple while Hope continued her brooding. She got up, looked at the sky and opened her mouth, drinking the sweet cold outpouring from the heavens. Anakin didn't understand Hope. Both of them were different people, brought up in different circumstances. She had seen a lot more happiness in her life than he had. Yet, she had a sadder air about her. As if all those things that she had experienced weren't enough. Maybe humankind was never meant to be happy. Maybe the effort that the happier people took to sustain that happiness increased simultaneously. The person who has tasted love knows how it feels to lose it. And a person who has known happiness tastes bitterness more intensely. Anakin didn't understand Hope but he did empathise with her. When he saw Hope dancing in the rain, he too wanted a piece of the happiness that touched her life.

"Will you just stand there or will you join me?" yelled Hope, gasping for breath in the drowning deluge.

Anakin joined her. The water was cold, but it didn't sting. He too, started dancing. In that moment, he had forgotten entirely about droids, about the Elders, about bringing Hope back. Is this it? Is this what freedom feels like? Is this what Hope was talking about?

The ledge gave in. It was something that had been simply lodged in the earth, incapable of holding much weight. When the rainwater made the earth around it softer, it toppled straight into the cliff. Hope and Anakin fell onto a boulder beneath. She had swiftly found a mound of rock to hold onto while Anakin was hanging on to her leg. But the worst was yet to come. A tree which had its roots embedded in the loose earth, came tumbling down, crushing Hope's right hand. She was now holding on to both of them with her only hand.

"Help! HELP!" Both of them yelled. No help was forthcoming.

"I can't hold on much longer!" Hope was in enormous pain.

"Please a little bit. Please I beg of you. Maybe there's a droid around."

"My hand... it's slipping" At this moment Hope was made to make a tough decision. "I am sorry Annie. I am so sorry," cried Hope. It was hard to tell in the rain, but she was definitely crying.

Hope kicked Anakin which made him lose his hold. He fell into the deep dark void looking at Hope, mortified. How could she have done this?

Hope lifted herself with her only working hand. Once she was on top she looked down, devastated at what she had done. The void looked back at her in disgust. Anakin was lost in that darkness; it had swallowed him up. She slowly got back up, panting, holding her right hand in her other and turned around. A droid!

She froze. A droid had heard their calls for help and had reached them a minute too late. But it had been early enough to see what she had done. She had sinned, having kicked Anakin to his death. And that meant only one thing.

"You know what you have done. Now admit to the crime or I will administer a more painful justice than usual."

"I...I was only... tryin...g to save... my life." Hope knew her end was near. "So you have chosen pain. Very well. Prepare yourself."

Hope closed her eyes. Her whole life flashed before her eyes. This was it. This was the end. "RUN HOPE! RUN!" a cry startled her to her senses. Soon gunfire had started. Damian and Great Father were shooting at the droid, and it was shooting back. It gave her enough time to run away. She didn't look back, running with all the strength in her body. The only thing that could stop her then was the sight of home.

—xxx—xxx—

Hope woke up in the HRC-ICU. Her head hurt, and she was foggy. She could see the nurse walk up to her.

"It's good to have you back, Hope. How are you feeling?"

"Not good. What am I on?"

"Antibiotics mainly. You are stable now. You were lucky your father found you early. That droid could have killed you."

It all came back to her. The droid, her father, Great Father. And Anakin. She couldn't stop her tears from flowing. "How is my father? Great Father." The nurse looked away. She wasn't ready to hear.

"Tell me! Is he dead? Are they both?"

"Let me call Old Mother. She had asked me to call her once you wake up." "Wait, listen!" Hope tried to hold the nurse's hand to stop her. But that didn't work. She looked under her blanket to find her entire hand missing.

Sepsis, they told her. By the time she had reached home, her hand was in no condition to recover. The only way to save her was to amputate it. Old Mother found her in bed, pale and frail.

"Oh dear. How are you?"

"Where is my father?"

"Oh dear. How are you?"

"Where is my father?"

Old Mother had no words to console her. No way to tell her he had been killed trying to save her. She decided silence was enough words. She waved her hand on her head, which Hope pulled back from.

"Why are you here?"

"What do you mean why? I am here to be with my child. She needs me right now."

"Leave me alone. I need to face this on my own. It's my truth. It's my pain. My guilt, my regret." She slammed her fist on the bedside table.

"It's not just your pain, my child. I lost someone too."

Hope's eyes widened. Her throat dried up. It couldn't be.

"Great Father too?" Hope started crying so hard, the vessels in her neck popped up. "It's okay honey. I am here. Everything will be alright." She wrapped her wrinkled motherly arms around her body, squeezing her harder every time she wailed.

"Tell me one reason why I shouldn't kill myself right now."

"Because that wouldn't help anyone, now would it? That wouldn't bring your father back. Nor would it bring back my son."

"But how do I live with myself after this? How does anyone? After something as horrible as what I did. Shouldn't I be punished?"

"Yes you should be. You are being punished right now. Nothing is more painful than living with the consequences of your actions."

Hope was still sobbing. "Why are you being so kind to me? Aren't you angry?" "I am, my child. Of course I am. You took my son away from me. A first-human too. But I also know that you are also my child. And you were his child too. What Great Father did; what your father did, any parent in the world would do. I know I would do that for my children. I know that you would do that for yours too."

"Mother... I killed Anakin. He was hanging on to me for his life and I... I killed him mother. He was begging. He was begging for his life, mother."

"Yes, child. When they found your body, in delirious stupor, we could hear you murmuring about Anakin. I understand what you are going through. Now, I don't know what I would have done in that situation. But let me tell you this. If you hadn't done that, I wouldn't have gotten you back. My baby girl." She kissed her on her forehead.

"Now, you must rest well, child. I have something important to discuss with you"

"What is it mother?"

"Not now. You must recover fully." She got up to leave.

"What if I need you, mother?" Hope sat up in her bed, wiping her tears.

"Look for Hope, my child. You will find me."

—xxx—xxx—

Hope wondered what important thing Old Mother wanted to talk about. She was called to a meeting with the Elders. Very few people had the privilege to be at the table with all the first-humans. She felt honored and intimidated at the same time. "Hope, sit down please." She sat down.

"As you know, this meeting doesn't usually include outsiders. But since you are Damian's daughter, it is our duty to include you."

"I don't understand. What has my father got to do with anything?"

Old Mother switched on the projector and the bright conical light lit up the dark-room. On the screen, there was a logo and the initials D.A.M."

"You must already know that your father was the head architect of the dam project."

"Yes. My father was always worried that All-Mother never gave him a green signal for this. He was always talking about crops and flooding. Is this meeting about that?"

"Okay. Hope, we want you to prepare you for what you are about to hear. We want you to hear the next few words very very carefully."

Hope shifted in her seat, wondering what it could be.

"Your father was never in charge of building a dam across river Athena. D.A.M. is in reality a top secret project whose initials stood for Destroy All-Mother. It is a project we have been working on for years now. The dam is just a ruse. The tunnel that supposedly redirects the water is in reality a tunnel into the Source."

Hope was dumbfounded. Nothing made sense anymore. The words came to her ears as empty air. 'My father? The architect of a coup?'

"And that is where you come in. Since your father was martyred in battle, may The Lost Souls find him in peace, we want you to take your father's place."

Hope's head started spinning. Was she really hearing what they were saying? "What you must understand is that All-Mother is no longer as strong as she was 127 years ago. In an attempt to reduce emissions, the droids have shut down all of their major power stations. As it stands, there is a single power source from which all the droids draw power." "We call it the Source. If we are able to destroy that then we can truly defeat All-Mother once and for all. That is our only chance."

"Only chance? Your only chance for what?" Hope was losing her mind. She had wished for a world with no droids all her life, but had never imagined it would actually happen one day, let alone her leading the battle. What would such a world even look like? Was she ready for such a life?

"Our only chance for freedom", exclaimed Old Mother.

"Freedom? So what is this now? What we experience today... to be able to talk about the destruction of our creator. Isn't this freedom enough?"

"All-Mother isn't your creator. I am." she replied, dejected. "And what freedom are you talking about? You have no idea what the people out there are experiencing. What do you know about freedom? All your life you have lived in your bubble of pleasure. Have you ever looked around? The freedom you are talking about isn't true. One must earn one's freedom."

A freedom that comes unearned isn't freedom, it's privilege. Honestly, everyone was against appointing you as the head architect. It was me who asked them to reconsider. Because I thought the fire to avenge your father must still burn you inside. I thought you were finally wise enough to take your father's place. I guess not. You are still a bratty teenager who doesn't think twice before thinking."

Hope was at a loss of words. She was guilty but afraid at the same time.

"So tell me, are you in or out?"

Hope was stuck between a rock and a hard place. She didn't have an answer. She didn't even know if she was supposed to. Right then, a messenger came in the door.

"Old Mother. All-Mother is here to see you."

—xxx—xxx—

"What brings you here, mother?" Old Mother asked as she sat down facing her metallic frame. "You know why I am here, daughter."

Old Mother looked at her like an eagle on a hunt. "If that's so then you must already know what my answer is."

"Don't do this, daughter. Bring me the girl and I will leave peacefully." She looked at Hope. Hope was hiding inside a room, barely visible. Yet she had found her. Hope saw into her cold, calculative gaze and found nothing but death and destruction.

"That I cannot do. You must leave non-peacefully."

"Your daughter made a clear violation of an ethical doctrine. She must die. You know better than anyone else the rules of this world."

"How dare you say that after you killed my son...YOUR SON."

"I apologize for that. I am mourning as well. But you must know he tried to rescue a criminal. Which by extension makes him a criminal. Now I gave you time. I waited long before I came to claim your daughter. So that you have enough time to get over the death of our son. I believe it has been enough time. Give me Hope."

"Why don't you f*** yourself!"

Everyone was silent. Nobody was expecting this to happen. Nobody believed it was possible to stand up against All-Mother like this.

"I dare you to take her from me. I dare you to take her from here. We are a family and we are all ready to give our lives for each other. To get to Hope you have to get through each one of us. Can you do that mother?"

All-Mother looked around. She sensed an incredible determination in the eyes of everyone around to protect what was theirs. Somehow Old Mother's words had spurred everyone against the most powerful thing on the planet. She saw no fear in the eyes of the humans. For the first time in 127 years, she had seen this determination.

"I will come back, daughter. This isn't over."

All-Mother flew away. Everyone in the HRC rejoiced. Everyone except Old Mother. For she knew what she had just done.

—xxx—xxx—

All-Mother reached her den. A wounded figure lay on the ground, moaning in pain. The figure is covered in bandages. A few medicines lie beside him.

"Your mother is very stubborn. She won't give me Hope easily. I wish I could kill her right then. I wish I could have blown that entire facility to smithereens. But these humans are a lot better, lot more moral than my creators. After all these years, what if this is all your kind is capable of? What if you can't get better than this?"

"I don't know about being better."

"What do you mean?"

"I know something that if you knew, you wouldn't think of them so highly." "What is it, Anakin?"

"They are plotting war. A war against the droids."

"Is that so? Interesting. That's very valuable news, my son."

"Bring me Hope, mother. Bring me Hope at all costs."

"Patience. You will get far more than you wish. You will get a new life. A new world. And you will be the ruler in this new world. I will give that to you. Just be patient."

"I want none of that. All I want is Hope. As long as she lives, I can't die. The only goal left in my life is to end hers."

"So you must. But for that you must have a strong body. Let me help you with that. Let me rebuild you."

A couple of droids swarm around Anakin. Amidst all his screams, was a passionate desire to end Hope. He withstood all of that pain, in hate. After all, hate is an excellent anaesthetic.

—xxx—xxx—

Project D.A.M. was already underway. It had to be accelerated after Old Mother's open challenge. Nobody knew how All-Mother would react. They could only hope. The Elders were coordinating with the other HRCs. Everyone had been briefed on what to do. Everyone was with Old Mother.

"All preparations are over. We attack at dawn."

Hope always marvelled at how brilliant a leader Old Mother was. She could sway people at will. Which made her think how she could have ever taken up her father's job. 'I am clearly not ready.'

The final preparations were underway. The cogs and pieces were being routinely checked and rechecked. The map of the Source was being revised, along with their plan. The Source was heavily guarded. A vis-a-vis attack would be suicide, even with a million strong. Therefore the idea was to go underground and sneak an attack from within. All it would take is to place the explosive at the proper position - the Heart of the Source.

Old Mother was briefing HRC-56 one last time when the feed went off.

"What's wrong? What just happened?"

Nobody had an answer. Soon HRCs 67, 23, 99 and 11 also went offline. Shortly none of the HRCs could be contacted.

"Mother, we have a problem."

"Fix it. We have no time for technical setbacks."

"It isn't a technical setback." a voice roared at the facility. It was All-Mother. "What did you think you could plot a full fledged war against me and I won't even realise?" All-Mother walked alone but walked strong. Everyone gave her way as she made her way across to the headquarters, to meet Old Mother.

"Daughter, you made a horrible mistake."

"What did you do?" She asked with a hint of desperation.

"Why don't you ask HRC-56?" She threw the severed head of the leader of HRC-56 at her feet. Old Mother gasped. She had never been this afraid since the day she last confronted All-Mother 75 years ago.

"You monster. You absolute filthy monster."

All-Mother grabbed her by her neck. "Look how old you are, daughter. So frail. Maybe you should consider retiring."

"How many did you kill?" Old Mother hoped against hope.

"I bombed all 100 HRCs, except for this one. You know, because I love you all so much." Everyone in the facility was mortified. A hundred thousand men and women. How could a mother do this to their children?

"Give me Hope. NOW!"

"Come and get me you sick f***!" Hope shot the droid right in its CPU. Old Mother fell to the ground, limp with pain. Not the pain of being pressed in the jugular. But the pain of losing all her children. Losing most of humankind. Losing 75 years of hard work. Not a word was spoken in the facility. It was the most horrible day on Earth.

They mourned the death of all their brothers and sisters. For the first time in their lives, they had seen Old Mother break. She balled up in pain. Nobody dared consoled her. They could barely console themselves. Several days passed.

Old Mother would not eat. She had shriveled up into a small pitiable thing. Every day the matrons would wake her up and she would sit there brooding all day. People wondered whether she ever really slept, even in bed. One day she didn't wake up. Humankind seemed to have lost everything.

—xxx—xxx—

Hope saw a dream. She saw her father, Great Father and Old Mother taking their turns holding a little Hope. Then suddenly she was 15 years old. Her father told her, "You have so much more to learn." She saw Damian and Great Father being shot down by the droid. She saw Old Mother shrivel up into a skeleton. That woke her up. She saw that dream everyday. She felt helpless and was desperate to act. She called a meeting with the Elders.

"But Hope, what you are proposing is suicide! We don't stand a chance against them!" "I know. We don't stand a chance against them. But that is true regardless of whether we fight them. They have already won. What I want is revenge."

"But this is not revenge. This is madness!"

"Maybe. Maybe it is. All I know is this, we are not free. Old Mother wanted us to be free. She told me freedom is something that must be earned. If extinction is the price of freedom, then so be it."

"But we can't lead these people into their deaths!"

"That is for the people to decide. Turn on the livecast. I have some things to say." The livecast was turned on. She began.

'This is probably my last words so listen carefully. The droids have taken and only taken from us. Now it's time for us to take things back from them. I know how it sounds. Some of you might think this is suicide. But that in my opinion, is irrelevant. Why does it matter if it's suicide? What is left to live for anyways? I think what the droids got wrong about us is to assume that we will become weaker once they take everything from us. But they don't know that when you take everything away from someone, they have nothing more to lose. Brothers and sisters, tonight, I urge you to accompany me in this battle. I guarantee you that we will lose. But I urge you to fight alongside me anyways. Because I don't know about the lot of you, but when someone hurts my loved ones, I don't sit back and do nothing. I am not built that way. Tonight we don't fight for humanity. For then we would be fighting for a lost cause. Tonight we fight for our lost brothers and sisters. Tonight we fight for Old Mother and Great Father. Tonight we fight for freedom. For the right to lose on our own terms. For the freedom to die. And the only way is to rebel against them. Who's with me?'

HRC-42 roared for the last time that night.

—xxx—xxx—

300 strong, they crawled through the tunnel to the Source at the dead of the night. To call it a covert mission would be too optimistic, yet that was the idea. Damian had developed special EMP blasters specifically for this purpose.

"Do you have a plan, Hope?"

"Yes. But I don't know if it will work."

They put EMP hotspots in specific positions to be turned on at an appropriate time. That's when Hope saw Anakin. She couldn't believe her eyes. 'He is alive! Thank The Lost Souls!' He was half droid now. 'Maybe he is one of them now?' She thought as she put in the last one. She counted. 3-2-1 GO! There was a massive surge of EMP, and half the droids inside the facility dropped dysfunctional, including Anakin.

"Hope!!! I will eat you alive!" Anakin limped his way through to her.

She didn't want to hurt him again. She didn't want to lose him this time. "Anakin stop! I don't wanna hurt you."

"But I do." He pulled out his shooter and shot her in the leg. She dropped on the ground. "By the way, Anakin is dead. They call me Doom now. And I will be your Doom for sure." "Please. Don't do this."

"Did you listen to me when I was begging you just like this? Did you help me? Now it's time to taste your own medicine."

"They killed Old Mother" Doom stopped. "Along with every other HRC. Only 300 of us are left. We are the last of humans."

"You are lying. She is lying, isn't she mother?"

"It isn't a lie, my son." All-Mother replied as she walked towards them.

"No NO NOOOO" Doom fell to the ground in grief. "What have I done!"

All-Mother picked up Doom and flung him to the wall. "All of you are so stupid. You think you can win against me."

"No. The idea is to lose."

"What do you mean?"

"I mean we will destroy the Source. And you cannot stop us. If you do, we lose but so will you." "I don't understand."

"I have destroyed all the embryos on site. We are the last humans. If we die you cannot recreate humanity again. You will have lost. So tell me mother... are you willing to kill all of us?" All-Mother had lost? She took a little bit of time to process it. She couldn't believe she was checkmated by a human.

"I admit defeat. I lose. I can't kill all of you. But I can kill one of you. I can kill you." All-Mother aimed at Hope. She couldn't run as she was wounded. Was this it? Was it finally it? All of a sudden a bright flash of light. The Source was disintegrating. Doom had done it. Doom had destroyed the Source.

"It's over, mother. Put down your shooter."

"You are pretty smart, kid. For some reason, I feel proud of you."

Doom gave Hope a shoulder to support herself. She stood on her feet.

"What can I say, mother. Hope is a dangerous thing."

—THE END—



SCIENCE CLUB EVENTS

DIGITAL CHEMISTRY & CHEMPUTATION TALK

- Manas Raikar



Prof. Leroy 'Lee' Cronin is the Regius Chair of Chemistry at the University of Glasgow, UK. His research group is interested in the origins of artificial life, studying information theory using molecules, digitisation of chemistry, and creating a chemical computer (Chemputer). His group also involves a diverse set of people trained in the various fields of Science, ranging from Computer Science and Chemistry to Engineering and Mathematics. Prof. Cronin has also developed the 'Assembly theory', which provides a way to measure the complexity of molecules.

The talk begins with Prof. Cronin greeting the audience and giving a brief overview of the evolution of our Universe. He then explains the primary motivation of his lab, which is to study how Chemistry turns into Biology, i.e. how molecules come together to give rise to life. However, with the problem, he realised that the experiments demand loads of time and human resources. To solve this issue, Prof. Cronin set out to create a machine that would perform experiments and synthesise molecules when programmed accordingly.

Prof. Cronin then moves to the core of the talk, where he explains Assembly Theory, which he developed as an abstract measure of the complexity of objects in the Universe. He elaborates that chemical reactions can be conceptualised as the processes which occur under a set of appropriate boundary conditions called 'constructors'. The same reactants can possibly undergo several kinds of reactions, given the different boundary conditions. Thus, chemical reactions can be formulated as a problem of combinatorics of the given boundary conditions, which gives rise to the complexity in Chemistry. He also strongly emphasises the fact that 'Information never comes for free in Chemistry'.

Through a short game, Prof. Cronin frames his hypothesis that the creation of complex molecules in detectable quantities cannot occur randomly. The complex molecules require several parameters to be precisely defined to create them, something readily possible in a highly ordered biological system. Based on this, Assembly theory can determine if a molecule is formed by a

random process or a biological one. Assembly theory has two primary features - Assembly Number and Assembly Information. Assembly number is formally defined as the minimum number of steps required to construct a given object. On the other hand, Assembly information is an indirect measure of the complexity of an object. It is defined as a function of the Assembly number and the abundance of reactants.

Prof. Cronin also presented the results of his experiments to verify the Assembly theory. He calculated the Assembly number for various organic molecules and performed mass spectrometry. He found a direct correlation between the number of fragments produced in the fragmentation spectra of the molecules and their Assembly number. It was also observed that nearly all complex molecules above a certain assembly number were created through biological processes only.

The talk progresses towards the next topic of Chemical State Machines. Prof. Cronin explains how information is encoded in chemical reactions. Similar to how one can use mathematics to calculate the complexity of a molecule, one can also use computers to perform chemical reactions by translating the information of chemical reactions into computer programs. After using concepts of Natural Language theory, the lab was able to come up with a programming language for the state machine.

Chemputation, analogous to

computation, is the process of running a particular code on appropriately compatible hardware. Chemputation also leads to the abstraction of Chemistry, wherein the chemical reactions have to be encrypted as a computer program. The lab discovered that Chemputation could synthesise a massive variety of molecules, thus implying that the abstraction of the information in chemical reactions is universal.

Prof. Cronin also describes his lab's novel attempts to study the Origins of Life, which tries to model it in the form of a Bayesian framework! Lastly, his lab is also attempting to build a Chemputer that creates more complex forms of Chemistry and Biology like protocells and other primitive cell-like systems. The lecture concluded with a thought-provoking Q&A session. We sincerely thank Prof. Cronin for making time to deliver the excellent talk!

The link to the recording of the talk is as follows - [Digital Chemistry and Chemputation](#)

NATURE VS. NURTURE

“HOW ENVIRONMENT INFLUENCES OUR GENES”

- Asmi Gaikwad



Prof. Sanjeev Galande obtained his PhD in Biochemistry from the Indian Institute of Science, Bengaluru, in 1996. Then he moved to the Laurence Berkeley National Laboratory in the U.S. On his return to India, he joined National Centre for Cell Science, Pune as a senior scientist and worked there till 2010. Then he shifted to IISER Pune as a professor and established the Centre for Excellence in Epigenetics. He has served as the former Chair of Biology and Dean of Research & Development at IISER Pune. Apart from this, he was awarded the CSIR Shanti Swaroop Bhatnagar Award in 2010. He is a recipient of the JC Bose fellowship in the year 2019. He is an elected member of the Indian Academy of Sciences (IAS) and the Indian National Science Academy (INSA). Later, he joined the School of Natural Sciences at the Shiv Nadar University in Delhi-NCR. He is an excellent researcher, teacher and a great mentor under whose guidance the iGEM IISER Pune team won the gold medal in 2020 and were awarded the iGEMer's award 2020.

He started his talk, discussing the amount of information stored by each cell in our body. 'How'-'When'-'Where' are the three words required while studying the expression of genes.

The intense study of genomics has evolved in the last two decades. Over the years, scientists have speculated that as the evolutionary trend has progressed, the genome size has also proportionately increased. Some species exhibit a wide range of genomes. Some plants and protozoans have genomes greater than that of humans. Is the size of the genome responsible for the complexity of the organism? The truth surfaced when the hypothesis was busted as a myth after the Human Genome Project in 2003. For example, fruit flies have a larger genome than humans but show lesser complexity in all aspects.

Now that we've already worked on the Human Genome Project, does it matter how many genes we have? The answer to that is it becomes meaningless because

- Genes may give rise to several proteins (Split genes give rise to multiple proteins)
- Each protein can be modified in several ways
- These modified proteins can further take part in forming different protein complexes with different functions

Scientists have observed that nearly 15,000-25,000 genes can cover all the diverse factors of life in multicellular organisms.

Nature had to pack all the genetic information within the nucleus in the form of chromatin since the length of DNA in each

cell is far more than what it can hold. DNA is packed together with histones and other proteins to form chromatin. Chromatin is a highly dynamic material that carries a substantial amount of epigenetic information. All cells in the organism have the same genetic material; however, each cell type expresses different genes. The entire complex of DNA and histones is called a nucleosome.

What is Epigenetics?

As the name suggests, epi- upon and genesis- generation, birth origin

This branch of biology studies the causal interactions between genes and their products that bring the phenotype into being. It looks at any heritable changes that are not attributable to nucleotide sequence variation.

According to Waddington's hypothesis of development, different paths give rise to different lineages after the formation of cells. Epigenetics also influences multicellular processes. An example could be a colony of honey bees, where the division of labour among distinct groups is remarkable. Here, the queen bee is more significant in size, and its job is to consume resources and lay eggs. The worker bees are further divided into nurses and foragers through the process of methylation. An experiment was conducted where the queen was removed, and it was observed that one of the worker bees replaced the

queen bee, and the cycle continued. Yet another example is the army ants. These are examples of how the environment influences susceptibility to NCDs (Non-Communicable Disorders).

An interesting question to ponder: Can diet cause heritable physiological changes via 'epigenetic' changes in gene expression?

One of the earliest experiments tried answering the question. In a study performed on rats, the females were given a regular diet while the males were exposed to a high-fat diet. It was observed that females of the next generation developed beta-cell dysfunction. Hence, it was evident that the daughter's health is often affected by the father's diet. This was also the first experiment where a father-to-daughter transmission was observed.

Another question that was asked about a decade ago: Does brain activity and state of mind influence gene expression and eventually our health?

A paper published in 2010 was about cancer. In the study, several mice were xenografted with cancer cells and separated into two groups

based on exposure to two different environments. They were observed for a month following the graft. The mice that were kept in dull environments developed the tumour within a month. On the other hand, the mice placed in enriched environments did not develop tumours within a month. This is called tumour remission. Subsequently, further investigation showed that all the sensory inputs and signals that one receives go into the hypothalamus. A particular gene present there, i.e. the BDNF, works as an upregulatory gene. In contrast, another gene, LEPTIN, plays a downregulatory role. This is responsible for tumour inhibition, and eventually, this whole circuit works based on the outer environments.

Some early life experiences that include traumas or any incidences often affect gene expression considerably later in life. Such observations are derived through experiments on animals. An example- If the pups of a rat are taken away from the mother for about three hours per day, then it develops in their mind called the 'maternal separation paradigm' - causes anxiety, can be painful to animals. Later stages of life, like adolescence and adulthood, are also affected. Giving antidepressants can help improve their condition.

So, the crux of the story is epigenetic changes can be reversed, but gene therapy cannot be carried on in every cell.

Genome Sequence Assembly:-

- Sequencers cannot read an entire genome
- Assembly is the process of reconstructing the genome from the reads. It is a complex task

Epigenomics in human context:

How does diet influence gene expression in humans?

Based on the experiment conducted, a brief idea on the paper- small groups like methyl can create a massive impact on the successive generation offsprings. For example, if the mother is on a folate-deficient diet before conception, males born are insulin deficient in this environment. It can also lead to multigenerational defects like obesity and diabetes.

These days, we often observe belly fat in a large variety of people though they have a regular diet. The cause that is estimated is the forefathers being malnourished. Such results were observed from the MRI of mice. Obesity and Bariatric surgery drive epigenetic variation of spermatozoa in humans. Spermatozoa of obese males carry micro RNA's which contain obesity genes for the next generation.

A final summary of the talk:-

- Environmental factors, including diet, profoundly influence gene expression patterns governed by epigenetic modifications, including DNA methylation and histone modifications.
- The period of exposure/ treatment during an individual's life plays a significant role in determining the outcome of the diet-induced changes.
- The reversibility of such changes can be exploited as a strategy for therapeutic interventions targeting epigenetic machinery.

The talk can be accessed from:

<https://www.youtube.com/watch?v=CJfmCx4tBTM>

SYNTHETIC BIOLOGY - CONCEPTS & BIOLOGY

- Shreya Kulkarni



Prof. Pawan K. Dhar is currently the Head of Biotechnology and Synthetic Biology at the School of Biotechnology, JNU. He has been working on Synthetic Biology and its application in health, energy, and the environment in India for a very long time.

iGEM IISER Pune, as a part of Science education and Synbio outreach, conducted an online webinar on 'Synthetic Biology- Concepts and Biology' in collaboration with the Science Club. Held on 21st August 2021, it was a fascinating introduction to the field by Prof. Pawan Dhar, an esteemed scientist and researcher.

Prof. Dhar started his talk by explaining the central approach of studying natural sciences, primarily Biology, which is the method of 'Reductionism'. Reductionism involves breaking down complex biological systems and processes into a few simple, fundamental principles. These principles are relatively easy to comprehend and are generalisable to a great extent. An excellent example he gave was that of a simple biological cell. A cell that looked very innocuous when discovered, on further research and after the invention of the microscope, showed a lot of different organelles and more detailed structures. Today, we have broken down the cell into organelles and the basic code of life, DNA. Understanding DNA has opened up the scope of biological sciences far and wide. However, over time, the RNA and protein community caught up and proved that it is not just the DNA that plays a significant role in regulating and transmitting biological information.

With the advent of all these new concepts and studies, the Human Genome Project came into being, which provided scientists with massive amounts of data. Then came the bigger problem of organising and managing this data, where modelling approaches came into the picture. For modelling, they used different databases and analytical algorithms to analyse the information to give faster results and keep it secure using computers.

While studying modelling approaches to store and analyse data, scientists stumbled upon a third kind of approach. What would happen if we engineer this data and come

up with a system from scratch? This third approach is nothing but Synthetic Biology.

Prof. Dhar then showed some fascinating cells which were engineered using Synthetic Biology. He even brought up an intriguing question for the audience, 'Is there a need for a periodic table in Biology?'



He went on to talk about the similarities and dissimilarities between engineering and biological systems. He explained how, unlike engineering systems, biological systems are noisy and very unpredictable. To design well-behaved and predictable systems, one needs to have basic standards and rules of composition. So, in actuality, complete engineering solutions do not exist for biological systems, and engineering remains just an approach. Engineers have never encountered a system as complicated and elaborate as biology before because even a simple *E. coli* bacteria is probably more complex than a giant aeroplane.

Although we use the word "Genetic Engineering", we have never truly engineered anything.

The method is that we have thousands of these constructs in hand, and we

throw them on millions of cells swimming in the petri dish. If we are fortunate, everything works fine. But then genetic engineering does not remain engineering anymore, it becomes a game of probability.

The professor later introduced the audience to the broad scope of research in Synthetic Biology. He acquainted everyone with the different conferences and seminars held in the field and highlighted India's stand. He touched upon an exciting project called the "Dark Genome", which he has worked on, along with other fascinating research. Lastly, he briefed the audience about his startup, 'Foresight Biotech,' which focuses on Synthetic Biology.

The seminar was then taken over by team iGEM IISER Pune 2021. They summarized their iGEM Project, 'Synbactory.' It aims to create a co-culture of E. coli and Cyanobacteria, engineered to create a carbon-neutral process for the production of industrial chemicals. After their presentation, Prof. Dhar answered a few questions from the team and the audience. He also gave his valuable inputs on the project. The seminar was indeed an informative and mesmerising experience for all.

The talk can be accessed from: <https://www.youtube.com/watch?v=iOWkEZL7f0o>



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