THE MICHRONICLE 2018-19

Through the looking lens

THE DEPARTMENT OF MICROBIOLOGY
ST. XAVIER'S COLLEGE (AUTONOMOUS), MUMBAI - 400001

What's Inside?

Editorial.....

Editor in chief
-Mathew Salazar

It is with great honour that I present to you ***"The Michronicle 2018-19".*** *This is the 11th edition of the magazine of the Department of Microbiology, which also celebrates its 86 "micro" years, this year.*

*As the name suggests '**The Michronicle**' is an account of the events that have been organized by the department over the last academic year. Thus, at its core along with demonstrating the academic accomplishments of the students and professors of the department, it is also a reflection of the writing prowess of the students and the mentorship provided by the professors.*

The theme of this year's edition is ***"Through the looking lens"*** *inspired by the Lewis Carroll novel* ***"Alice through the looking glass"****. In this sequel to Alice in Wonderland, Alice crosses over into a bizarre universe on the other side of a mirror. Not unlike Alice, as budding microbiologists we too are faced with a bizarre, beautifully complex universe on peering through the looking lens that is not just our microscope but our scientific temper. Just as Alice explores the unfamiliar, we too attempt to shed light on various fields through different articles in this magazine.*

My team and I have worked hard to see this magazine come to fruition, which would not have been possible without the support from our professors, writers and every single person who contributed to it in one way or another. It has been a joy and a privilege to bring this edition of The Michronicle to you. Hope you have a good read.

From the teacher's desk.....

Message for Michronicle:

"I see nobody on the road", said Alice. "I only wish I had such eyes."

-Lewis Caroll in 'Through the looking Glass'

The theme for science for 2019 was 'science for people and people for science'. Science has always attracted the curious and willing to learn and we hope you will become one of these 'people for science'. You have all looked through the looking glass and experienced the wonders of the Microbial world. We hope that you will further explore this delightful world of Microbiology. It is a great outlet for those who find satisfaction in exploration and innovation.

'Science for people and people for science' highlights the importance of not only pursuing science for knowledge and individual glory but also the application of science to the betterment of mankind. Microbiology has great potential to help people by improving living conditions through advances in fields like industry and medicine. We are confident that you will use your skills and education to better the society and environment around you. We hope that you, the people for science, make your science truly for people.

-Prof.Miriam Stewart (HOD)
Dr.Karuna Gokarn
Prof.Sangeetha Chavan
Dr.Aparna Talekar
Dr.Pampi Chakraborty
Dr.Pradnya Gogte

Student Articles

The benefits of biofilms

-Avipsa Hazra
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(2019-20)

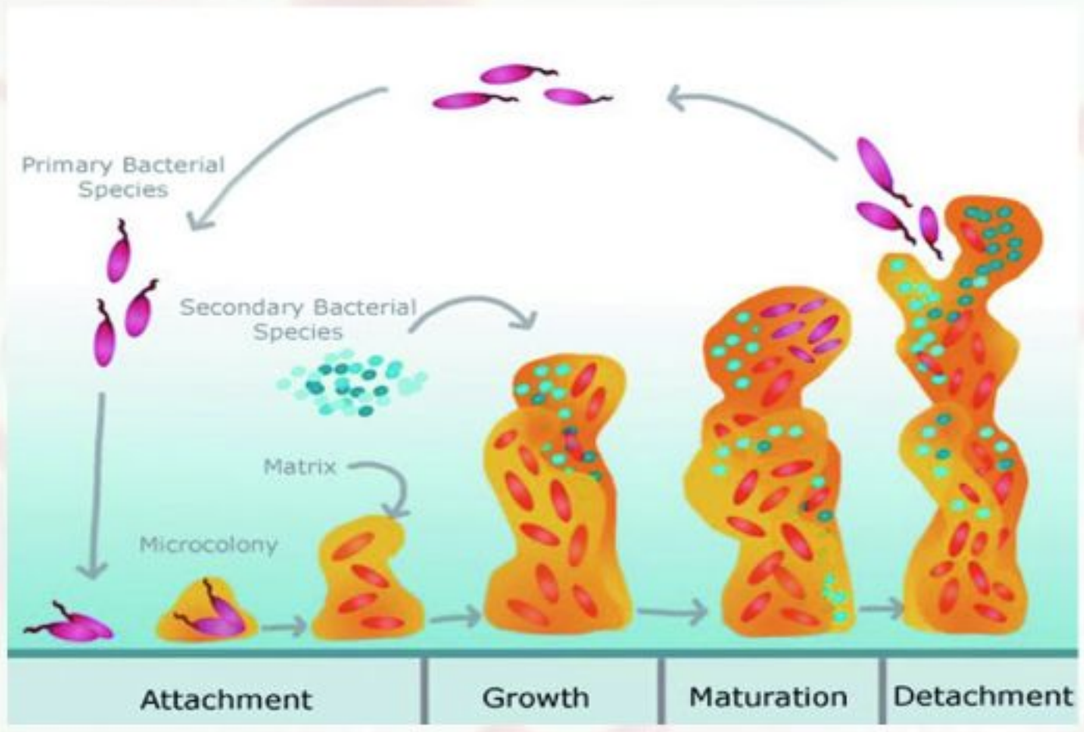
Biofilms are a collection of one or more types of microorganisms that can grow on many different surfaces. Microorganisms that form biofilms include bacteria, fungi and protists. One common example of a biofilm is dental plaque, a slimy build-up of bacteria that forms on the surfaces of teeth.

What are Biofilms?

Bacterial biofilm is infectious in nature and can result in nosocomial infections. According to the National Institute of Health (NIH) about 65% of all microbial infections, and 80% of all chronic infections are associated with biofilms. Biofilm formation is a multi-step process starting with attachment to a surface then formation of micro-colony that leads to the formation of three-dimensional structure, and finally ending with maturation followed by detachment. During biofilm formation, many species of bacteria are able to communicate with one another through a specific mechanism called quorum sensing. It is a system of stimuli to coordinate different gene expressions.

How are Biofilms Formed?

Microbes produce extracellular polymeric substances (EPS) such as proteins (<1-2%), DNA (<1%), polysaccharides (1-2%) and RNA (<1%) and in addition to these components, water (up to 97%), is the major part of a biofilm which is responsible for the flow of nutrients within the biofilm matrix. Biofilm formation is commonly considered to occur in four main stages: (1) bacterial attachment to a surface, (2) microcolony formation, (3) biofilm maturation, and (4) detachment or



dispersal of bacteria, which may then colonize new areas.

The slimy films start forming when initially free-floating bacteria adhere to surfaces in aqueous environments and start 'laying their roots'. To stay sticky, the bacteria excrete a glue-like substance called EPS that's effective at anchoring them to all kinds of materials, from plastics to soil to medical implants such as pacemakers. In time, layers upon layers of EPS are added. After a period of growth, a complex 3D structure emerges which is packed with water channels on the inside that facilitate the exchange of nutrients and waste products.

A fascinating thing about biofilm formation has to do with how the bacteria communicate. Pathogens can instruct each other where to position themselves through quorum sensing. This phenomenon allows a single bacterium to sense how many other bacteria are there in its close proximity. If the bacterium senses there's a dense population surrounding it, it will be inclined to join them. Remember, strength lies in numbers. Sometimes clumps of biofilm can break away from the main mass and establish themselves on a new surface. These new pioneers will continue to extend their slimy film until they form a new, bigger colony.

How do they help us?

When oil accidentally winds up in nature (as seen in oil spills), microbes slowly break down oil particles. Since oil is primarily made of carbon, there are a variety of bacteria that break down small oil molecules for food. With this line of thinking, it's feasible to say that biofilms can be potential tools to clean up environmental messes. Using biofilms in this way is an example of bioremediation, or returning an environment from an altered state back to its natural one with the help of microorganisms. Though collecting oil and running it through a biofilm filter of some sort isn't a common method to clean up oil spills today, it may be an interesting option to explore in the future.

Biofilms even have their place in the mining industry. Quite often, valuable ore is separated from normal rock but in the presence of water and oxygen, certain types of leftover crushed rock can create a sulfuric acid solution if left alone. Once the reaction takes place, this acid and other runoff are hard to clean up and can pollute nearby water sources. But if you take out a part of the equation, the rock material won't become acidic and can be disposed of differently. It turns out that placing biofilm-forming bacteria that need oxygen on these rocks will strip the element from its surface and disable this acid runoff from forming.

In addition to bioremediation, biofilms can be used in biofilm trickling filters to treat wastewater .In this process, biofilms are grown on rocks or pieces of plastic to clean waste from the water slowly trickling through. On a small scale, this process is efficient enough, but most municipal water treatment centres still rely on larger quantities of bacteria to treat wastewater. Biofilms also benefit other organisms in nature. Underground, microorganisms will form a biofilm around the rhizosphere, or the area between roots and soil, in plants. Chemical interactions in this symbiotic relationship grant both parties access to nutrients that would otherwise not be available to either. Biofilm formation on plant roots is one of many examples of why biofilms are ecologically important.

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Chalking the chocolate.

- Bipasha Kulkarni
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(2019-20)

Can you imagine a life without chocolates? Well, isn't it the easiest way to bring a smile on a child's face? And would 'Chocolate Day' ever have a meaning? Phew! We're lucky to be born after the 16th century because until then chocolate only existed as a bitter, foamy drink in Mesoamerica.

This is how we got through a bitter beverage to the modern-day sweet chocolate bars:

Dating back to the 1900 BCE, the Mesoamericans (flourished in central Mexico) learnt the techniques to harvest the beans of the native Cacao tree. According to the Mesoamerican mythology, a feathered serpent God, Kukulkan - as known to the Maya and Quetzalcoatl – as known to the Aztecs, gifted humans the heavenly cacao fruit. Since then, the Mesoamericans and Aztecs were so fascinated by the fruit and its beans that they used them not only as currencies and rewards to brave soldiers but also in rituals. Chocolate, a drink then made with crushed dried cacao beans, cornmeal, chillies in water or wine, was only drank at royal ceremonies and feasts. The people of Mayan culture were the first to use cocoa or chocolate as a romantic gesture.

In 1519, Spain was the first European country who explored seas and encountered chocolate. It's the Spanish who gave this bitter invigorating concoction a sweet touch by adding honey, sugar or vanilla. This version of 'chocolate' very soon became a popular delicacy in Spanish courts and aristocratic homes, who also dedicated classic chocolate-wares for drinking it.

The chocolate tree, *Theobroma cacao* as ascribed by Linnaeus means "food of the gods" (Greek: *theos* - god, *broma* - food). The cacao is the bean while cocoa is the product that is made from it. This native Latin American Cacoa tree was introduced to West Africa in 1824 by the Portuguese. And now, Cote d'Ivoire along with Ghana produce half of the world's chocolate. Globally, around 40-50 million people depend on this tree for their livelihood, while most farms producing them are not owned by the companies that make chocolate.

A part of the flavour is formed in fermentationof cacao beans. Approximately 2500 beans are produced by the cacao tree. The fruit is the size of a small honey melon containing about 30-40 beans surrounded by pulp. The fermentation and drying of the beans are done at the farm that grows the cacao trees. After harvesting, the pods are split open with hammer or machete to reveal the beans. These beans are now piled into a heap and covered with banana leaves or are placed in a covered box. The pulp surrounding the beans is inoculated with a consortium of microorganisms from surroundings. As the pulp has an acidic pH of 3 to 3.5 and a high sugar content (about 10%) only a few microbes can thrive. This is the reason why the fermentation usually goes well, even if it is not inoculated with a starter culture.

The fermentation follows a microbial succession of a wide range of yeasts, lactic acid and acetic acid bacteria. Starting with the yeast followed by lactic acid bacteria that eat up some of the citric acids present naturally in the pulp. The pH rises, thus favouring the growth of acetic acid bacteria which convert some of the alcohol into vinegar thereby generating heat (45-48°C). The alcohol and vinegar penetrate the bean killing it and arresting its growth. Now the beans can no longer germinate. A heap of cacao beans fermented for five to seven days can contain about 108 microbes per gram. Beyond this, there is a rise in bacilli and filamentous fungi that might cause off-tastes and foul odours. By now the walls of the cells are broken down and different substances interact thus giving a flavour to the unprocessed product. Furthermore, sun-drying of the beans until they are microbially stable also enhances the flavour. The farmers sell these fermented and dried beans to the producers who roast them at around 121°C, killing most of the microbes. From here on each brand work their magical recipes to give us the myriad cocoa delicacies.

Nutritionally speaking, dark chocolate can do wonders when consumed in moderation. It contains iron, copper, magnesium, zinc and phosphorus. Choose 70% dark chocolate or higher to benefit from most flavanols. However, with a high percentage of cocoa solids, caffeine content the bitter taste also becomes high. These flavonols help to keep heart-related ailments at bay, improving the blood flow thereby lowering the risk of high blood pressure. Moderated consumption may also contribute to an increase in insulin sensitivity reducing the risk of diabetes!

So eating and gifting chocolates is both healthy and romantic! ☺

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Bacteria and Bees

-Kshitija Aherker
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(2019-20)

Look for the trees,
their leaves
and the bees:
Legs of amber and yellow,
Wings of brown and golden
Stingy little fellow-
Of buzz and pollen and sun.
Tiny but prodigious,
Apian and conspicuous.

Bees are the perfect pollinators leading a very busy & active life. They are also the long-term models for behavioural studies symbolising community, brightness and personal power along with wealth. These Lilliputian insects are of great importance when it comes to economic and environmental facet. Ranging from wild solitary species to highly social and managed species, honey bees like *Apis mellifera*, play key roles in natural and agricultural ecosystems worldwide.

As pollinators, bees are cornerstones for terrestrial ecosystem stability and key components in agricultural productivity being the largest group of pollinating insects. In addition, bees also help in overall growth and development of flora.

All animals are associated with a diverse community of microbes, commonly referred to as the microbiome. Bee-associated microorganisms include a diverse set of bacteria, fungi, viruses and protists. Different bee colonies have different strains such as the rock bee- *Apis dorsata* (Apidae), The Indian hive bee- *Apis cerana indica* (Apidae), The little bee- *Apis florea* (Apidae), The European or Italian bee- *Apis mellifera* (Apidae), Dammer bee or stingless bee- *Melipona irridipennis* (Meliporidae) similar to the human microbiota. This interaction of bees with the microbial entities present in their gut is termed 'mutualism'. The microbial metabolic activities have a notable impact on overall development and health of honey bees.

A diverse community of bacteria are used by bees to turn fresh pollen into a long-term food store. Lycopodium spores include the major preservative in this case. Also, they need a range of bacteria to help them fight off infectious diseases. Without a diverse microbiome the bee bred can be more vulnerable to mould. This will result into ultimate shortage of food for hive. In addition, bees colonize new habitats, resulting in better adjustment with the environment. Four Proteobacteria (*Gilliamella apicola, Snodgrassella alvi, Frischella perrara, and Bartonella apis*), which mostly reside in the ileum. Two Firmicutes (*Lactobacillus spp. Firm-4 and Firm-5*) and one Actinobacterium (*B. asteroides*), which are predominantly found in the rectum.

Bees pick up different strains of bacteria from plants when they are foraging for food and these are transferred to bee bred within the hive. Different metabolic niches in bee gut are occupied by bacteria which plausibly are seen dependent upon one another with reference to food supply. Bacteria associated with bees have been hypothesised to be involved in the formation of nest products and inhibition of microorganisms that can cause spoilage in the storage pots. Storage pots essentially include the containers such as boxes, cans, bottles where honey is stored.

The intestines of honeybees, for example, contain bacteria that help digest food and stimulate the immune system of the insects, as per an article on Science Daily. These bacteria include Bacillus species as major highlight such as *Bacillus oleronius, Bacillus stratosphericus, Bacillus altitudinis*. The bee hive also contains useful microbes like *Lactobacillus rhamnosus, Lactobacillus acidophilus* and *Bifidobacterium lactis* some of which produce antibiotics thus inhibiting the growth of fungi.

While numerous more bacterial life are kindred with bees, here's something to be au fait with: The two species *Gilliamella apicola* and *Snodgrassella* are the most eminent as far as the 'living' of bees is concerned! *G.apicola* turns simple carbohydrates into energy through glycolysis – a process that occurs in virtually all living things. Normally, when glycolysis is finished, the leftover energycontaining molecules are fed into a second energy-production pathway: the Krebs cycle. However, *G.apicola* misses the gene required for Krebs's cycle. Therefore, *Gilliamella* essentially hands the end products of glycolysis to *Snodgrassella alvi*, which does have the necessary genes for the Krebs cycle, but not the ones for glycolysis. We can as, for all in all say that it's a metabolic match made in heaven!!

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Kuru,the laughing disease

-Irin Ann Paul
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(2019-20)

Ever heard of some strange and intriguing funeral rituals that people across the globe actually perform? In that case ,the 'Fore people' would be the strangest. It's because their funeral ritual ultimately paved its way to the strangest of diseases, commonly known as the 'laughing disease'. Fore is a tribal community in the Okapa district of Papua New Guinea, a country in the South Western Pacific. In the early 20th century, the tribe began developing a fatal neurological disease that killed 2 percent of the tribe's population every year.

The epidemic was at its peak in the 1950s.The Fore people believed that it was a curse and blamed sorcery for the loss of lives.

In 1961, a medical student, Michael Alpers came across the news and was interested in it. After graduation, he found himself as a medical officer in Papua New Guinea's Kuru affected regions. Living among them for almost a year, he convinced the people to allow him to collect autopsy samples of the brain from the deceased. Alpers then got along with Carleton Gajdusek, an American scientist who was interested in studying the disease, injected the samples into chimpanzees and decided to observe them for ten years. Two years into the experiment they observed behavioural changes in the chimps similar to the symptoms of Kuru. Symptoms like body tremors and disability to hold things, as observed in humans were observed in them. Further, a neuropathologist proved that the brain pathology of Kuru affected chimps and humans were exactly the same.

This provided evidence for the transmissible nature of Kuru. Alpers and Carleton wrote their research papers within a day, according to which Kuru was identified as a new category of infectious disease that causes degeneration of the brain and nervous system, and was capable of crossing the species barrier. Carleton Gajdusek received a Nobel prize for his Kuru-related works.

The strange ritual

Alpers combined his experience with the data collected by the patrol officers, scientists, missionarie and anthropologists and linked Kuru with the funeral ritual of the tribe including cannibalism. The Fore people showed their love and grief to the deceased by eating their bodies. According to the tribe, "if buried, the body would be eaten by worms. If left on a platform, it would be eaten by maggots.So it's better to be eaten by their own loved ones". It was the responsibility of the women to cook and eat the bodies. Boys were excluded from this once they turn 10. This practice of consuming the infected human brain led to an epidemic killing 25 percent of the tribe's women and comparatively fewer men and children.

The puzzle completed!

The actual cause of the disease was a mystery until later, when the infectious prion proteins were discovered as the pathogens. Prions are inanimate misfolded proteins that multiply in the brain to form clumps and lesions which hinder the normal brain processes. Subsequently, they trigger the

normal proteins to fold abnormally.This broke all previously assumed rules because of the fact that prions lacked their own genes. It was also the first new pathogen identified in more than a century.

Ensuing this, cases of Creutzfeldt Jakob Disease (CJD), a human variant of the Mad Cow disease, surfaced. CJD had similar symptoms as that of Kuru. It was later identified that both were due to the infected prion proteins. They were types of spongiform encephalopathy diseases where the brain becomes sponge-like due to the infection affecting mainly the cerebellum. In 1970, Alpers proposed that Kuru had spread from a single case of CJD, which is not transmissible unless an infected brain is consumed .

Stages of Kuru / symptoms

Kuru is also known as the 'laughing disease' due to the random and sudden compulsive laughing or crying bursts. The term *Kuru* literally means 'to shiver' or 'trembling in fear' (in Fore language). The following are the three stages of the disease :

1. Some loss of body control and lack of coordination of voluntary muscles (Ataxia), difficulty in posture and balance and dementia.
2. Inability to walk, body tremors and involuntary jerky movements (Myoclonus).
3. Loss of speech and difficulty in eating (leading to malnutrition leading to the maximum number of deaths).

Diagnosis

1. Neurological test.
2. EEG (Electroencephalogram).

Treatment

There is still no treatment discovered yet for Kuru. Prions remain infectious even when preserved in formaldehyde for years. The only prevention was the prohibition of the ritual. Currently Kuru cases have almost vanished due to the prohibition, the last one being in 2010, where an elderly woman was diagnosed with Kuru, which surfaced years after the actual infection probably in her childhood.

A genetic mutation

Interestingly, survivors of Kuru carried a genetic mutation (V127) which made them resistant to both Kuru and CJD. This mutation was likely to be present in the population before the Kuru epidemic, but became much more common when it provided a genetic advantage.

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Gut microbiota

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(2018-19)

The gut microbiota is composed of a large number of bacteria, archaea and fungi that occupy the human gastrointestinal tract. Earlier, detection of these organisms was done using culture-based techniques. This limits the extent of study since many of the microbes cannot be cultured. Improved methods target the 16S ribosomal RNA, allowing the analysis of more organisms as this gene is present in all bacteria and archaea. Short segments of the 16S ribosomal RNA are sequenced to identify and distinguish different species. The Human Microbiome Project provides detailed information about human microflora to date.

Most of the organisms present in the gut tend to have similar functions and are of the phyla Firmicutes, Bacteroidetes, Actinobacteria and Proteobacteria. The bacteria present in the gut are generally anaerobic while aerobic bacteria are present more in the cecum. *Candida, Saccharomyces, Aspergillus* and *Penicillium* are some of the fungal genres that have been found and another large part of the population is composed of Archaea.

Bacteria from the surroundings and the mother immediately colonize the GI tract after the birth of a baby. Though the exact source of these bacteria is not well understood, it is seen that the mode of delivery affects the microbial population. There are large numbers of lactobacilli in the tracts if the baby was born through vaginal delivery which corresponds to the abundance of *lactobacilli* in the vaginal region. Babies born through C section, on the other hand, show less of these species and are colonized by anaerobic species in their early days. With age, the microbial diversity and population in the infant increases and becomes more adult-like. Each person has a unique microbial composition and acquiring these organisms can depend on initial exposures such as breast milk, the hospital environment in relation to the oxygen concentration in the gut, diet, antibiotics used and so on.

These microbes provide a range of benefits to the host. Gut bacteria are able to break down complex carbohydrates which human hosts are unable to. They metabolize carbohydrates to produce short-chain fatty acids, mostly acetate, propionate and butyrate. Muscles require acetic acid. ATP production in the liver requires propionic acid and butyric acid supplies energy to gut cells. The epithelial cells of the GI tract are quick to absorb these molecules as they are important in carrying out important cellular processes including gene expression, chemotaxis, differentiation, proliferation and apoptosis.

Gut bacteria produce essential vitamins that the host cannot synthesize. Some of these include vitamin K, riboflavin, biotin, nicotinic acid, pantothenic acid, pyridoxine and thiamine. Animals, plants and fungi cannot produce vitamin B12. Therefore lactic acid bacteria play an important role in its synthesis. Vitamin B9 plays a key role in DNA replication and repair. It is mainly synthesized by *Bifidobacteria*.

The normal flora of the gastrointestinal tract can also prevent the colonization of pathogenic bacteria by competing with pathogenic bacteria for nutrients or attachment to cell surfaces by secreting toxic substances. The composition of organisms in the GI tract differs in different people and can change according to age, ethnicity, lifestyle and diet.But large variations in the gut microbiota may point to intestinal and extraintestinal

diseases. Over presence of some bacteria may play a role in inflammatory disorders such as inflammatory bowel disease. Studies show that there is a reduction in the amount of *Lactobacilli* in the faecal samples of IBS patients compared to a healthy control. An increase in Proteobacteria and Firmicutes and reduction in Actinobacteria and Bacteriodetes was observed. Loss in the microbial diversity is said to affect amino acid synthesis, the integrity of cellular junctions and increases inflammation, which can explain some IBS symptoms. The gut microbiota consists of a rich and diverse population of microorganisms that contribute to the health and stability of the human GI tract as there is a symbiotic relationship between the host and the microbiome. Studying variations in the microbiota, in the physical, molecular and biochemical level can further the understanding of the role that microorganisms play in health, disease and disease control.

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Extremophiles : A journey towards limitless life

-Michelle
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(2018-19)

Climate change has been an issue of concern all around the world. The survival of life is thus questionable as it is difficult to adapt to these extreme living conditions. But there are some organisms that are able to thrive let alone survive in these conditions. We call them the extremophiles (adaptability to extreme conditions).This is used as a broader term and they can be further classified into subgroups: thermophiles (adaptability to extreme temperatures),barophiles (adaptability to extreme pressure), acidophiles (adaptability to highly acidic conditions) and so on.

The first extremophiles were found around the 1960s deep below the soil, which could not be penetrated by light and was hence called the dead zone. Now of course ,we know that many organisms can survive here. As science has progressed we have found organisms that can do much more and survive in practically unthinkable living conditions. They are well distributed throughout the phylogenetic tree with most organisms in Archaea, a few Bacteria and Eukarya. Organisms showing similar extremophilic character are seen in various parts of the phylogenetic tree giving us an idea about how these organisms have evolved in their environmental niches and also suggesting that they may have different strategies to overcome the same issue.

***What leads to these adaptations in an organism?**

Whenever an organism comes across a new environmental stress they may adapt to it and thus take part in evolution. The survival of the fittest requires such adaptability, organisms do this by making a number of changes in their metabolism.

This explains why adaptability is seen in harsh environments. But questions can arise as to how some organisms like *Deinococcus radiodurans* (able to withstand 5,000 Gy of ionizing radiations) survive in conditions that are not even seen on the Earth. This can be attributed to the extreme flexibility shown by these organisms while encountering any changes. Moreover there are some organisms which are not only tolerant to these conditions but also require such conditions for their survival, this is because through the course of their evolution and as a result of living in extreme conditions these have completely given up their normal metabolic functions in exchange for alternative pathways.

***What changes do these organisms make?**

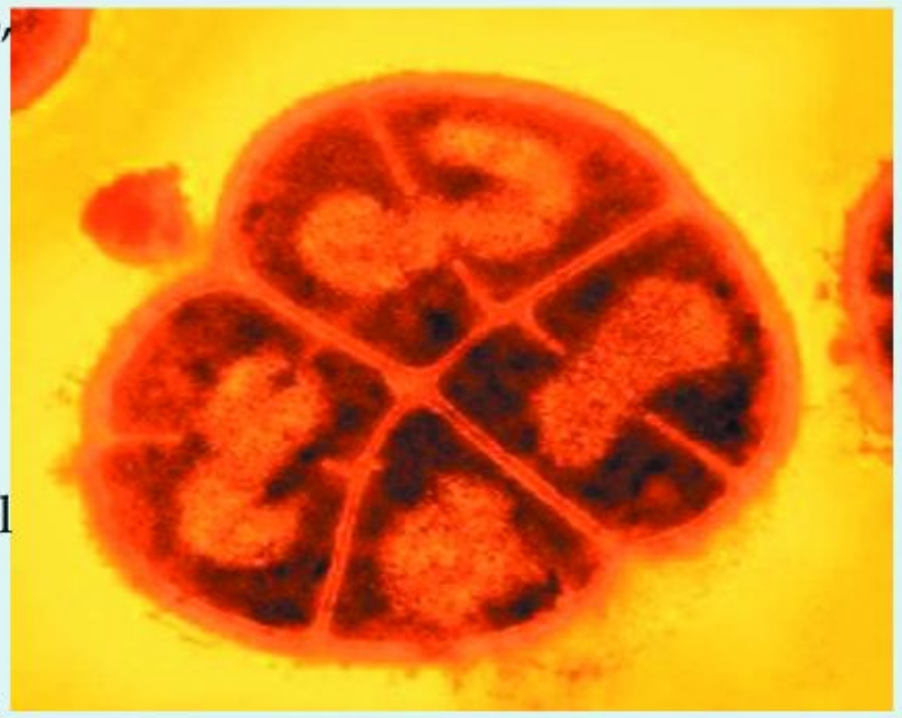
Various organisms employ different techniques to achieve their extremophilic abilities. In case of thermophiles, in order to withstand hot temperatures, the cellular components that are usually heat sensitive, have to show heat resistance. Glycerol, ethers and lipids found in the membranes can increase stability against hydrolysis at high temperatures. Also ,the thermal resistance of the DNA double helix is improved by reverse gyrase, a unique type 1 DNA topoisomerase that causes positive super-twists for stabilisation. Moreover the enzymes seen in these organisms also show higher heat resistance. When talking about temperatures as high as the 100ºC range we see that the metabolism products like ATP are hydrolysed faster, hence they must be resynthesized at biologically feasible rates.

Now considering radiation resistant organisms like *Deinococcus radiodurans* there has to be a mechanism that restores DNA once it has been denatured by high amounts of radiation. For this purpose the organism has multiple copies of its genome stacked on top

of each other, these multiple genomes increase chances of retaining at least one copy of the genome are higher.
The proteins and pathways involved suturing of this DNA are being studied extensively. A special *RecA* protein has been considered an important part of the repair pathway. There are other extremophiles that can live in extremely alkaline conditions by regulating their internal pH and special enzymes that can withstand highly alkaline environments. Some survive in oxygen deficient areas by tweaking their metabolic pathways.

***How can these organisms help us?**
To date, only a few a extremophiles have found their way into large scale use. Thermostable DNA polymerases used in polymerase chain reactions, various enzymes used in the process of making biofuels, organisms used in mining and carotenoids used in food and cosmetics industries are a few examples. The use of extremophiles in pharmaceuticals and medicine has been very useful in combating numerous health issues. Most of these organisms are useful in making antibiotics, antifungals and antitumour molecules. This should not come as a surprise as after all most of these organisms have been fighting against each other in their quest for survival. Antimicrobial peptides have been found in *Halobacteriaceae* as well as *Sulfolobus* species. Diketopiperazines have been shown to affect blood clotting functions as well as having antimicrobial properties. These are found in in halophiles like *Naloterrigena hispanica* and *Natronococcus occultus* and have been shown to activate and inhibit quorum sensing pathways. These pathways are seen in pathogens like *Pseudomonas aeruginosa* , hence this can be an alternative treatment for some drug resistant species. Organisms found in stagnant pools of water in Lechuguilla caves have shown the ability to kill breast cancer cells while leaving healthy cells intact. *Deinococcus radiodurans* can join DNA fragments and hence can possibly help us to bring dead cells back to life. Another very interesting contribution of extremophiles in medicine is an alternative vaccine delivery system. Several microorganisms produce internal gas vesicles, small gas filled proteinaceous structures, mostly seen in halophilic organisms. These structures have been engineered in *Halobacterium* species NRC-1 to generate a recombinant form that expresses portions of the simian immunodeficiency virus on the external surface . These recombinant vesicles have have shown a strong antibody response and immune memory. Typically, vaccines derived by recombinant methods require the addition of adjuvants to bring about a large immune response. However, in the case of these recombinant vesicles the organisms own polar lipids can be used as adjuvants.

Research suggests that along with potential to help develop countless new medicine to treat diseases, they might also possess abilities to combat global warming and pollution. Some recently discovered extremophiles use methane to produce energy, this can help reduce methane levels in the environment. A thermophile that uses iron to digest food and produce energy could help in generating electricity from waste and remove toxic metals from the environment. These organisms also have the potential to efficiently process biomass into biofuels like ethanol.



The world of extremophiles has been a key area for research in the field of astrobiology. It can help us understand how life began on earth when the environmental conditions were very different from how they are today.This also will help us know more about LUCA (last common universal ancestor) which may have

itself been an extremophile.

The study of life on other planets and galaxies is also possible with the study of extremophiles. Giving us a hope of survival on planets other than the earth. Upto 50% of the world's biomass comprises of microorganisms but uptil now only 5-10 % have been discovered . Not all these are extremophiles so the possibilities of these amazing species are still not known to us. A more detailed study of these extremophiles can help us find solutions to a number of problems. On an ending note, even though we have extremophiles and technology as a helping hand, it is our responsibility to change our behaviour towards maintaining our environment.

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Cancer Vaccine Therapy

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Cancer, a dreadful disease, is the second leading cause of death globally. An estimate of 9.6 million deaths due to cancer was reported in the year 2018. The earliest evidence of this ailment has been found in the fossilized bones of the Ancient Egyptian mummies.Cancer happens when the cells inside our body start dividing abruptly to form a tumor. Only a malignant tumor causes cancer, not benign. Some cancers do not form tumors like leukemia.

Now, let's talk about vaccines. Vaccines help us protect ourselves from infectious diseases. They are made from weakened or attenuated (killed) microbes. Vaccines work by stimulating B lymphocytes to produce antibodies that act against the invading pathogens and help the body fight that disease.
Cancer vaccines are of two types:
a) **Prevention vaccines** are those vaccines given to healthy people to keep certain cancers from developing. They protect the body from the pathogens that can cause the disease. Two types of cancer prevention vaccines approved by the U.S. Food and Drug Administration (**FDA**):
i) HPV vaccine- HPV vaccine protects against infection with human papillomaviruses(HPV). HPV is a group of more than 200 related viruses, of which more than 40 are spread through direct sexual contact. Amongst these, two HPV types cause genital warts, and about a dozen HPV types can cause cervical, anal, oropharyngeal, penile, vulvar, and vaginal types of cancers. Some of the HPV vaccines are Gardasil, Gardasil 9 and Cervarix. The first HPV vaccine, Gardasil, was available in 2006.
ii) Hepatitis B vaccine- This vaccine prevents *Hepatitis B* virus infection(HBV). Engerix-B and Recombivax-HB are examples of Hepatitis B vaccines and are approved by the U.S. FDA. Chronic HBV infection can lead to hepatitis, liver cirrhosis and hepatocellular carcinoma(HCC). HCC is one of the five major cancers in the world population. The world's first universal HBV vaccination program was launched in Taiwan in July 1984.

b) **Cancer treatment vaccines**, also called therapeutic vaccines, are a type of immunotherapy. These vaccines work to boost the body's natural defenses to fight cancer. Doctors give treatment vaccines to those people who are already diagnosed with cancer.These vaccines work against cancer cells. The idea behind treatment vaccines is that cancer cells contain substances called tumor-associated antigens. These antigens are not present in the normal cells and, if present, are at very lower levels. Treatment vaccines can help the immune system learn to recognize and react to these antigens and destroy the cells that contain them.

Cancer treatment vaccines may be made in three different ways-
1) From the patient's own tumor cells. This means that the vaccine is custom-made so that they cause an immune response against features that are unique to the particular cancer type.
2) From tumor-associated antigens found on cancer cells of many people with a specific type of cancer. Such a vaccine can cause an immune response in any patient whose cancer produces that antigen. This type of vaccine is still under immense research.
3) From the patient's own dendritic cells. Dendritic cell vaccines stimulate the immune system to respond to an antigen on tumor cells.One dendritic cell vaccine has been

approved named Sipuleucel-T which is used to treat some men with advanced prostate cancer.

A different type of cancer treatment called Oncolytic virus therapy is sometimes described as a type of cancer treatment vaccine. It uses an oncolytic virus, a virus that infects and breaks down cancer cells but does not harm normal cells.

Now, how do cancer vaccines work?

Antigens are substances on the surface of cells that are not normally part of the body. The immune system attacks these antigens with an objective of getting rid of them. Once successful, the immune system keeps a memory that helps it respond to those antigens in the future.

Cancer treatment vaccines boost the immune system's ability to recognize and destroy such antigens. Often, cancer cells have cancer-specific antigens on their surface that the healthy cells lack. When these cancer-specific antigen molecules are given to a person, they act as antigens. These molecules stimulate the immune system to recognize and destroy the cells that have these molecules on their surface. Most cancer vaccines also contain adjuvants, substances that help strengthen the immune response.

Developing a cancer treatment vaccine that works is difficult because of the following reasons:

1) Cancer cells suppress the immune system and that's how the cancer is able to develop and grow in the first place. Researchers are currently using adjuvants in the vaccines to try to fix this problem.

2) Cancer cells develop from a person's own healthy cells. As a result, the cancer cells may not look harmful to the immune system of the body and may be ignored.

3) Larger or advanced tumors are hard to get rid of using only a vaccine.

4) Elderly and very sick patients tend to have a weak immune system. Their bodies may not be fit enough to produce a strong immune response after vaccination. This limits the efficiency of the vaccine. Also, some cancer treatment vaccines might damage the patient's immune system, thereby, limiting the ability to respond to a vaccine.The cancer vaccines are still under chemical trials. These have been proved quite effective

when tested on the patients, but still do not give the desired results. The most important problem with cancer is that the cancerous cells evolve from the patient's own healthy cells. The complexity and heterogeneity of cancer cell expression also add to the problems in making the vaccine. Researchers are trying their best to come up with such vaccines that will have the capability to eradicate cancer permanently from the world. This is going to take time,but the future seems to be promising.

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Wee Brains!

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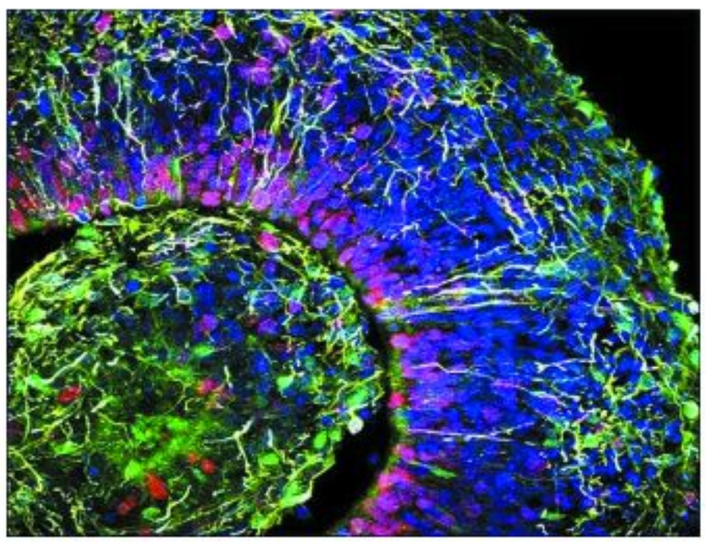

Ever heard of brains growing in your petri plates?? Sounds like supercool sci-fi stuff right? But guess what? Scientists are growing mini brains with neural activity similar to that seen in a preterm infant and are calling them the brain organoids- Tissues that function like brains but are not a part of an organism.

What are "organoids"?

Organoids are a group of cells grown in laboratories into three-dimensional, miniature structures that mimic the cell arrangement of a fully-grown organ. They are derived from stem cells or induced pluripotent stem cells, and are crafted to replicate tiny organ-like structures that do not achieve all the functional maturity of human organs but often resemble the early stages of a developing tissue.

Till date we have been using either animal models or cell lines to study diseases and extrapolate it to human biology which have a little resemblance to normal or diseased organ. Thanks to organoids, scientists can now culture tiny versions of each organ that can partly replicate complex functions of mature organs. Organoids of small intestine, kidney, heart, stomach, eyes, liver, pancreas etc. are some that have been developed in the laboratory.

Scientists took cells from the skin and fed it with different cocktails of sugars, proteins, minerals and vitamins until recently in 2013 they found the "perfect recipe" to transform these stem cells to brain organoids. This was just the start a series of mind baffling events.

As the organoids developed, scientists used tiny electrodes to measure any electrical activity they generated. After just two months, the researchers detected scattered brain-waves of roughly a single frequency, much like that seen in the immature human brain. By 10 months, the mini brains' activity zapped at a range of different frequencies and became more regular, just as it does in the maturing human brain as new neuronal connections are made- so much activity from just a fraction of the brain! Scientists also transplanted the lab grown brain organoids to adult animals. The transplanted organoid had integrated with the animal brain, grown new neuronal connections and responded to light. These are seen as a step towards potential "humanization" of host animals.

So, are we finally on the verge of creating Frankenstein?! What if they do start to feel something? Will they be distressed? And how would we know it? Keep hopes low, science maniacs and rejoice, ethical lunatics! The organoid has the same tissue types as the full-sized brain but not organized in the same way i.e. it is similar to an airplane that is reassembled at random. We can still study the engine, the wings and other parts but the plane can never fly. Most importantly they are unable to interact with the outside world. We learn to interact with our environment by receiving signals from our sensory organs and reacting in turn. Without this feedback loop, the organoids can never develop consciousness. Why do we need such a thing? Studying of the brain has been extremely difficult. Scientists earlier

used animal models, autopsies and imaging techniques to study it. But it had limitations, especially when trying to study complex, intrinsically human characteristics or diseases such as schizophrenia, alzheimer or autism spectrum disorder, which are uniquely 'human' diseases. Effects of pathogens like Zika virus on our brain can now be successfully studied. Brain organoids will also bring insight into how the brain is formed during the early developmental stages, something that has been studied for more than a century and still puzzles scientists.

Brains do define us. They are the seat of our thoughts, personalities and behaviors and cultivating it in a small plastic dish might be morally troubling for many and adventurous for many others. Although organoids have only 100 thousand neurons compared to the 100 billion in our brains, yet, as the organoid technology advances, academic ethics committees will be busy for quite some time. Till then keep hoping to see the Frankenstein for real!

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Why does Botox® not kill you?

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It's active ingredient is the most toxic protein known to humans, yet it is therapeutic for a variety of neuromuscular ailments.

With an intravenous and intramuscular median lethal dose (LD50) of 1 nanogram per kilo of bodyweight, the botulinum neurotoxin (BoNT) by a large margin outdoes other biochemical agents in its gram for gram potential for fatality. The median lethal dose of any drug is a quantitative assessment of its toxicity, and it is fixed at that administered dose which causes the death of 50% of a tested population. The lower the LD50 of a drug, the more toxic it is. For comparison, the oral lethal dose for the BoNT at 0.000001 g/kg is much smaller than that of hydrogen cyanide—0.0015 g/kg. A testament to the extreme deadly potency of the BoNT is the estimation that more than one million people can be killed if a single gram of crystalline toxin is evenly dispersed and inhaled.

The botulinum toxin is excreted by the *Clostridium botulinum* spore-bearing bacilli. The spores of this bacteria are widespread in soils and waters across the world. *C. botulinum* spores germinate when they encounter anaerobic environments, and the vegetative bacilli thus formed produce the botulinum toxin. The toxins cause the poisoning known as botulism, which mostly occurs as a food-borne intoxication; the bacteria can cause infections as in the cases of wound botulism and infant botulism. The risk for contracting food-borne botulism from improperly processed and incorrectly preserved foods that may contain the spores and allow them to germinate and produce toxins is high, as in a process of canning gone wrong.

The botulinum toxin affects the nervous system due to its action at the neuromuscular junction—the site of communication between a nerve fibre and a muscle cell. Usually, the motor neuron releases acetylcholine from its presynaptic end into the synapse, and once the receptors on the muscle cell bind the acetylcholine muscular contractions are generated.The BoNT binds irreversibly to the neuromuscular junction on the neuronal side,

and it will block the release of acetylcholine into the synapse (the gap between the nerve cell and the muscle cell) enzymatically, effectively causing paralysis by preventing muscular contractions. Botulism presents characteristically with a descending paralysis from head to toe and bulbar palsies—loss of function of the nerves originating from the upper part of the spinal cord where it connects to the brain—which include symptoms like blurred vision, dilated pupils, double vision, drooping eyelids, light sensitivities, difficulty swallowing, and problems speaking. Following this the skeletal muscles weaken starting from the upper body, and upon reaching the diaphragm and breathing muscles cause death by respiratory failure. In light of the horrific presentation of botulism which can ensue from an intoxication caused by

proteins weighing a millionth of a gram, one wonders how the BoNT came to be the first microbial protein to be used through injection for the treatment of human diseases. In 1968, after a time in WWII when the botulinum toxin was a prime candidate as a biological weapon, Alan Scott, an ophthalmologist, regarded the toxin as a potential injectable therapeutic for eye muscle hyperactivity. Scott experimented with BoNT on simian ocular muscles, and himself recollected, "An injection of a few picograms would induce paralysis confined to the target muscles, long in duration, and with no side effects whatsoever." To be noted here is that a picogram is one trillionth of a gram, or twelve orders of magnitude smaller than a gram. Successful studies on human beings were followed by the approval of the toxin as a therapeutic in the treatment of strabismus (squint), blepharospasm (twitchy eyelid), and other facial nerve disorders in 1989 by the US Food and Drug Administration. The Allergan company had acquired rights for distribution of the toxin, which they named Botox®—today the most well-known brand of botulinum toxin of serotype A.

Since then, the toxin has been used for treating several conditions in which the deliberate paralysis of specific muscles is beneficial to patients. The drug has wide-ranging applications in ophthalmological, gastrointestinal, urological, orthopedic, dermatological, secretory, painful, and cosmetic disorders as seen in the treatments of dystonia (repetitive muscle contractions causing fixed abnormal posture), spasticity, wrinkles, chronic migraines, excessive sweating, and other conditions. The BoNT is available through only a few companies because its manufacture, storage, and distribution are difficult, complex, and dangerous, and tightly regulated by government vigilance over the feared toxin. A Bloomberg article states that a baby-aspirin-size amount of powdered toxin is enough to make the global supply of Botox® for a year. Even though the botulinum toxin has been poised to kill, as a drug it is tamed by constitution in its pure form and in incomprehensibly minute quantities (as explained under the picture below). Treatment with the botulinum toxin is rendered largely innocuous and effective due to its localized and limited effect in the injected muscles, the appropriate and safe doses, heavy labelling and regulation by the FDA, and its high price. The essential toxicological adage by Paracelsus, the dose makes the poison, is never more apt than when man fights diseases with poisons. In this case, that poison is the deadliest protein that exists.

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Are sanitation standards causing allergies? An overview

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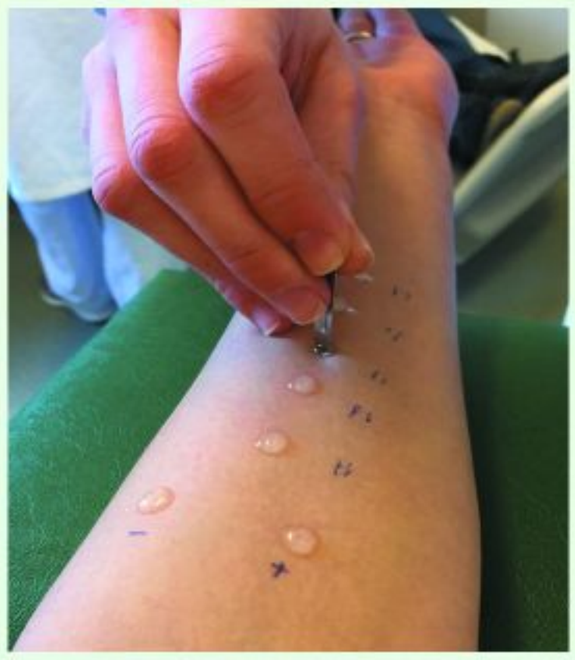
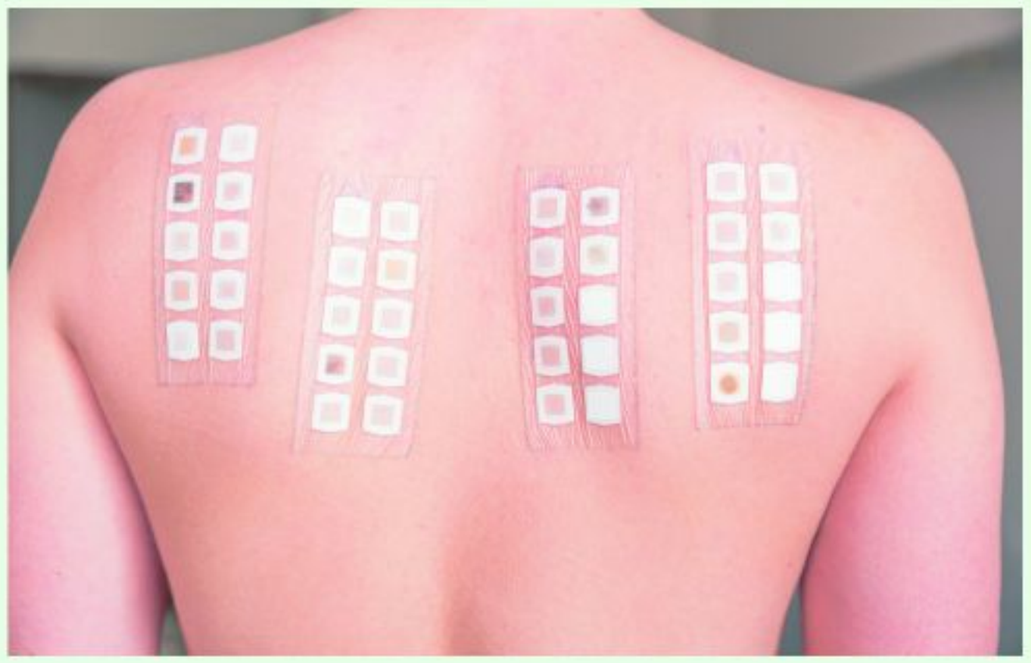
Medical techniques currently have led to various advancements such that humankind has been able to deal with diseases that were considered terminal for a very long time. The plague, cholera and other similar illnesses are now under control such that most cases now can be treated with simple medication and proper medical supervision, but can pose a danger without some proper treatment. There still exist issues in modern medicine that cannot be completely dealt with, one of which is allergies. Allergy is a hypersensitive response of the immune system to substances (allergens) which come in contact with the body, either by physical contact, inhalation, exposure or any other method. An allergic person's immune system reacts to allergens as if it is a dangerous pathogen, therefore eliciting an immune response trying to destroy it. The action mechanism is very much similar to that generated in response to a common cold or the flu. Allergies are becoming extremely common nowadays. According to public health authorities, about 20% of the people in North America and western Europe have allergic rhinitis or an allergy to pollen. Another study revealed that treating children's food allergies is costing approximately 25 billion dollars a year. Allergies are caused by specific substances called allergens. They are usually categorised as a drug, food, latex insect, mold, pet and pollen allergies. Dust, pollen, pet and food are some of the most common allergens. An individual's sensitivity to allergens varies from one person to another, so three people with the same allergies could show very different symptoms to the same allergen. The mechanism of allergies is dependent on one antibody. Most people have IgE-antibodies (immunoglobulin E) which works as a defence system against the infections. However, when IgE-antibodies respond to common environmental antigens as hostile substances, the immune system treats it as a pathogen or virus, causing an immune response that could potentially be lifethreating in some cases. Most common symptoms seen in case of allergies are a runny nose, sneezing, coughing, nettle rash, swelling, itchy eyes, sinus pain, vomiting, diarrhoea etc. These symptoms are not only characteristic for allergies, hence it is usually advised to consult a doctor. Patients who have had severe allergic reactions often carry an epinephrine autoinjector with them, such as the EpiPen, Twinject or Anapen, providing immediate relief which is followed by medical supervision. Various tests can be performed to check if a person responds to the commonly known allergens:

- Blood test: This involves measuring the levels of IgE antibodies produced by the immune system when exposed to the allergen. This test is also known as the radioallergosorbent test (RAST).
- Skin prick test: This is also known as puncture testing or prick testing. The skin is pricked with a small amount of a possible allergen. The skin is then observed for symptoms such as itchiness, redness, and swelling.
- Patch test: A patch test is performed to check for eczema. Special metal discs with very small amounts of a suspected allergen are taped onto the individual's back. The skin is then checked for a reaction after 48 hours.

Drugs can help treat the symptoms of an allergic reaction, but they do not provide a cure to the allergy. Few of the drugs used are Antihistamine (which blocks the action of histamine), decongestants (helping with a blocked nose in cases of hay fever, pet allergy, or dust allergy), leukotriene receptor antagonists or anti-leukotriene



Skin prick test



Patch test

(anti-leukotrienes can block the effects of leukotrienes which are the chemicals that cause swelling) and steroid sprays (help reducing nasal congestion).

The increase in the number of people suffering from allergic reactions is explained by the 'hygiene hypothesis' as first outlined by Dr David Strachan who proposed that a lower incidence of infection in early childhood could be an explanation for the 20th century rise in the atopic diseases such as allergies. The presence of microbes is believed to assist in the function and development of the human immune system and plays a protective role against allergies. Due to the changes in the sanitation standards introduced during the industrial revolution, the exposure to microbes has reduced that would otherwise boost the immune system. This is believed to result in a compromised functioning of the immune system and an increase in the incidence of allergies.

Another theory explaining allergies is the OF theory. The Old Friends (OF) Mechanism was proposed by Rook in 2003 and argues that the vital microbial exposures are not colds, measles and other crowd infections but rather microbes already present during primate evolution and in hunter-gatherer times when the human immune system was evolving. OF microbes are environmental species that inhabit indoor and outdoor environments and the largely non-harmful commensal microbes acquired from the skin, gut and respiratory tract of other humans. During human evolution, before the development of the modern medicine, the OF also included organisms such as helminths, *Helicobacter pylori* and hepatitis A virus that could persist for life in hunter-gatherer groups which were needed to be tolerated. They all, therefore, activated the immunoregulatory mechanisms. Both the aforementioned theories are still at early stages of research but there has been significant data collected in both cases. Whatever be the theory, people suffering from any kind of allergy are required to make significant lifestyle changes and need to always be cautious of exposure to the allergen.

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"A transformation that's not Griffith's"

The role of gut microbes in transforming blood types.

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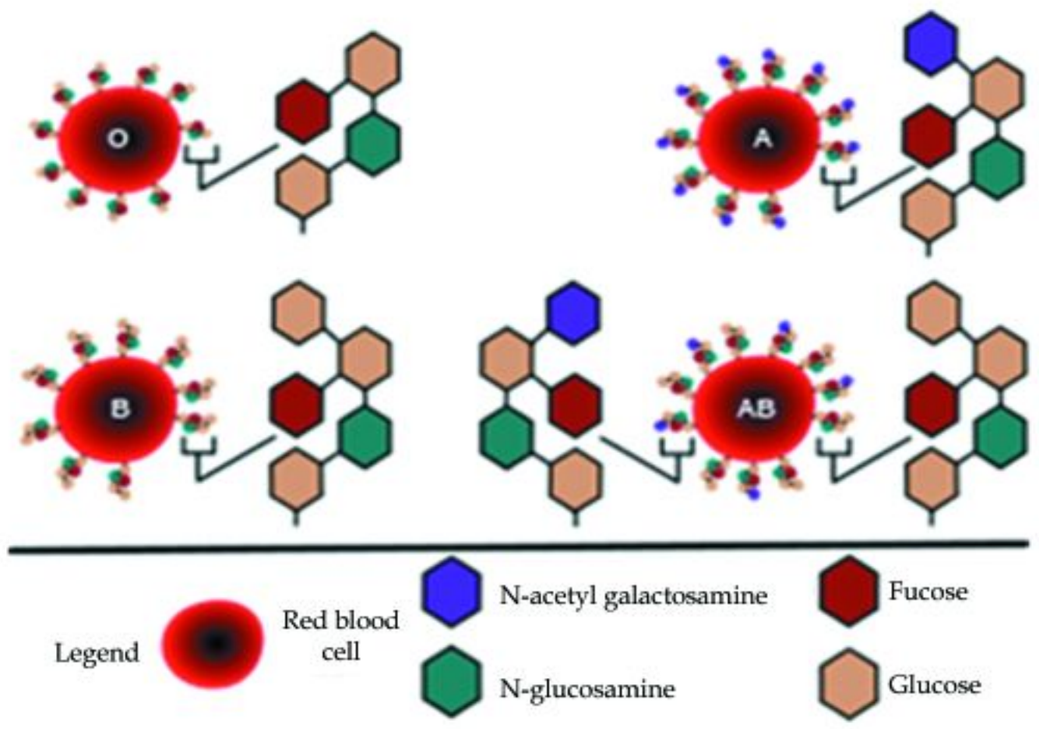
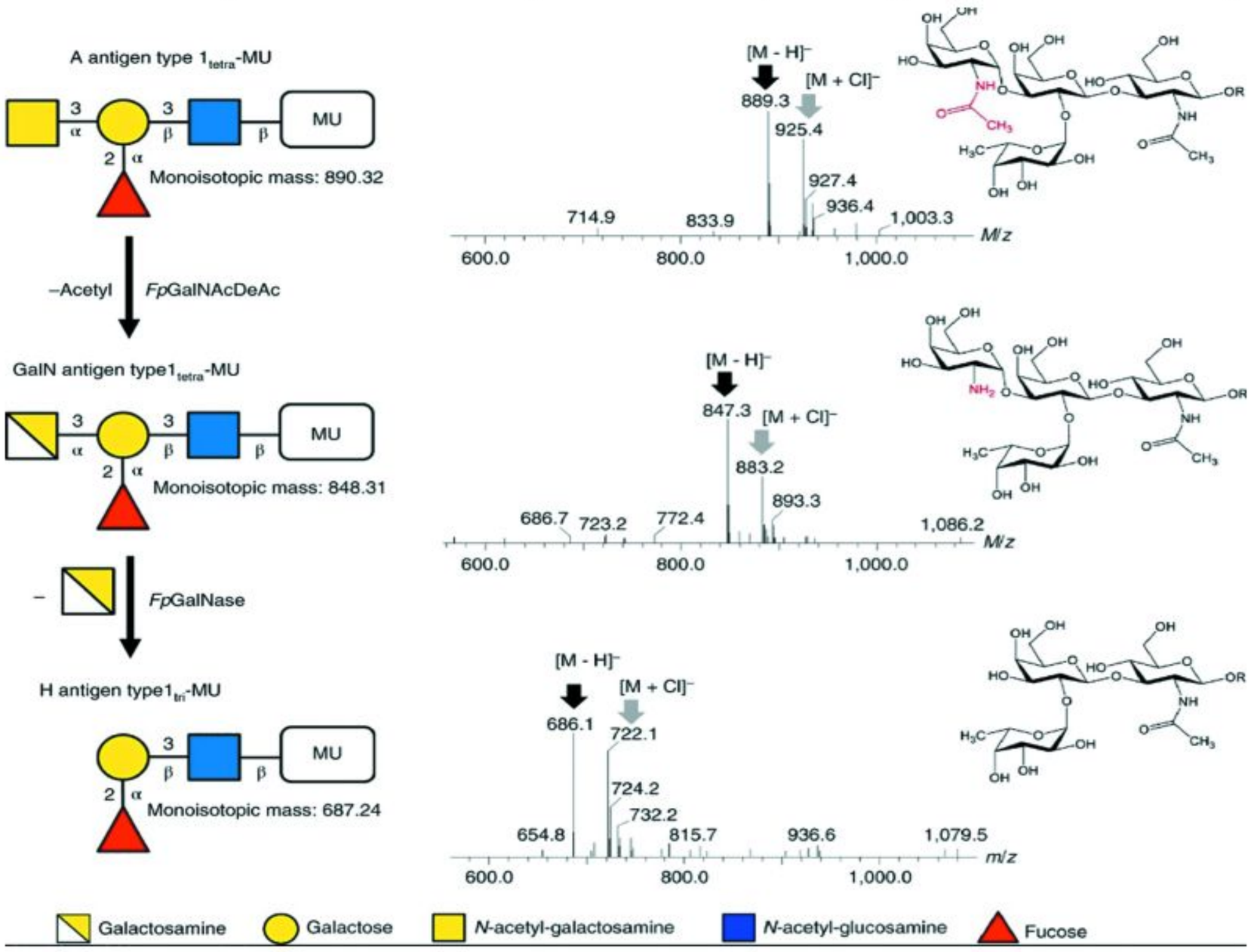
Our gut is home to a diverse range of microorganisms and is thereby, largely studied by scientists worldwide. The variety of microbes found in there is just astonishing. Right from the abundant *E. coli* to the rarer *cyanobacteria*, these organisms perform a plethora of functions for the well-being of the host (that's us!). One of the more recent and novel findings was the presence of an enzymatic pathway facilitated by a microbe (*Flavonifractor plautii*) that is present on the walls of our gut, that would transform A blood group to O.

A person with A blood group can only accept an A or O donor, nothing else. If given otherwise, the body triggers a very powerful immune response against the blood cells that leads to their lysis. These blood types are classified by the type of structural antigens present on the erythrocytes. Type A blood has the A antigen (primarily a carbohydrate structure terminating in an *a-1,3-linked-N-acetylgalactosamine* molecule on the cell surface) that separates A type blood from B type which has the B antigen (carbohydrate terminating in galactose) and AB which has both. But O type blood is devoid of any antigen and hence, is the universal donor. Transfusion of O type blood in any individual does not elicit a negative immune impact and that's why there is an ever-increasing demand for O blood everywhere.
This was one of the major reasons for this study to catch the attention of scientists at the University of British Columbia.
Biochemically, this reaction can be explained as the cleaving of the sugar molecules from the blood cells so as to make the A or B type into O. This result could also be obtained industrially, but very large quantities of cleaving enzymes were required that make this process economically unfavourable. Hence, scientists at the University of British Columbia employed metagenomic studies to find viable genes for enzymes that could bring about this transformation easily.The study, published in Nature magazine talks extensively about a "metagenomic library" cultivated from the faecal samples of an AB+ blood type donor. After sequencing and examining plausible hits 11 fosmids (a DNA vector used to generate



clones of DNA for large fragments to make stable libraries in complicated genomes) were identified using the Metapathways software, and the responsible organisms identified. They were:
1. *Bacteroides sp.* (GH109)
2. *Flavonifractor plautii* (GH36 &GH4) along with a CBM.
3. *Collinsella tanakaei* (GH36) GH:Glycoside Hydrolases.
All of these genes were expressed and the enzymes they produced expressed and analysed. The GH109 was unable to give the required result in the absence of an additive to the blood which isn't realistically possible.The particular GH36 from *Collinsella* was inefficient in cleaving the A antigens even in the presence of a crowder (a chemical that

concentrates the enzyme on the surface of the cell) The successful organism turned out to be *Flavonifractor plautii*, the fosmid of this organism was named NO8. The obtained gene products (CBM32, GH4 and GH36) were tested individually first which did not yield the expected result but then, a combination of these enzymes was tested. The secret ingredient of this organism was the CBM32. CBM refers to a carbohydrate binding molecule which along with the glycoside hydrolase (GH) was found to cleave the A antigen (tetrasaccharide) completely and transformed it into the H antigen (trisaccharide) which is present on the O type blood cells. The target of these enzymes is the terminal N-acetyl-galactosamine that is converted into an intermediate that hinders the binding of the anti-A antibody. The FpCBM32 converted the A antigen to an "active compound" and then the successive addition of FpGH36 released galactosamine, leaving behind the H antigen trisaccharide.



CBM32 is classified as a deacetylase (FpGalNAc deacetylase) and GH36 is a galactoseaminidase [FpGalactosaminidase (FpGalNase)]. These enzymes work under specific pH and without the presence of a crowder and any other additive in minimal concentrations (as less as 6microgram/ml) but most importantly, they have a narrow substrate specificity range and are hence still limited to A+ blood type. These do work on B+ but the action is not as fast and substantial as in the case of the former. On the other hand, the GH4 gene product did not cleave any A antigen substrates and hence does not play a crucial part in this multi- enzyme pathway. Since the enzymes would have to be cultivated in-vivo, the organism should be well studied as well! *Flavonifractor plautii* is an anaerobic, gram positive rod shaped Clostridiales that is very common in the gut microbiome. But obtaining an isolate of this organism from the sample is tedious. It usually causes infections when found in the bloodstream and causes sepsis making it a potential threat for in-vivo systems. so, if gene products of this organism are going to be used directly in human systems (a very unlikely possibility), genetic engineering would be required to make the microbe non-infectious. We know that this process happens in the gut because these organisms were acquired from a stool sample. The question that arises is why do these organisms contain such enzymes? What purpose do these enzymes have in these microbes' survival in the stomach? The answer lies in Mucins. Mucins are highly glycosylated proteins present on the goblet cells and other mucous membranes in the gut. These sugar protein entities are consumed by these bacteria and so the evolution of these enzymes was for the sole purpose of attachment of the bacteria to the wall of the gut.Mucins are structurally very similar to the sugars present on the blood cells and for that reason, these organisms can be biotechnologically utilised to transform blood sugars and convert A type to O to aid transfusion.

Let's talk about the prospects of this study, these enzymes have proved that they can effectively and profitably transform blood groups, this is because of their low concentration requirements, top-class kinetics and easy extraction methods. All of this indicate that this could be the future of blood transfusions. A large percentage of the world's population has blood group A and so, the substrate specificity is not a setback. This type of experimentation crosses no ethical boundary, the only apprehension being that whether this conversion changes anything else in the cell or not. This research, spear-headed by Stephen G. Withers and published in Nature Microbiology, has thrown light on the importance of the normal flora of the human body. Once again, microbes have shown great potential to help the world to equalize a serious deficit that can not only help in transfusions but also in organ transplantations. It indeed is true that the smallest (microscopic even) things in the world when used smartly and with patience, can make the greatest impacts on the world, just ask the microbiologists!

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Nanomedicine: A nano level therapeutic approach

-Sayandrila Paul
FYBSc (2018-19)

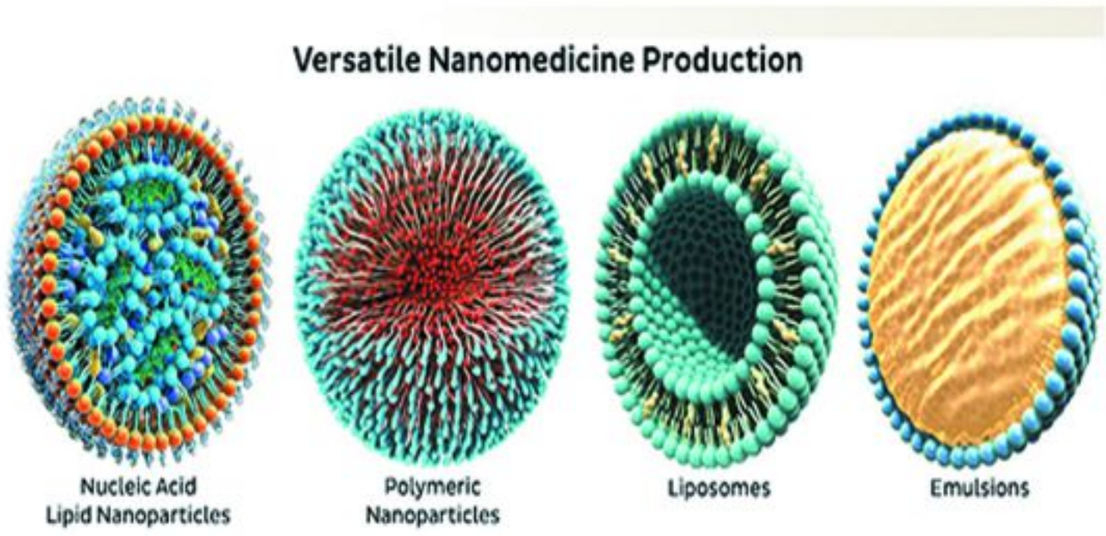
WHAT ARE THEY: NAME SAYS IT ALL!

The very basic definition of nanomedicine is the use of engineered end products that consist of nano scale physical attributes (also encompass similar chemical responses like a drug) and their application to the therapeutic usage against a disease. Different examples of nanotechnological products include liposomes, nanocrystals, emulsions, iron carbohydrate complexes, so on. Nanomedicines are being tested against various diseases like cancer, inflammatory diseases, infections, anaemia, and other chronic and acute diseases. One of the major classification of nanomeds are on the basis of routes of administration- they can be oral, topical and parenteral. It is important to note that these nanomedicines demonstrate traits similar to a particular drug but they fall under the clad of non biological drugs as they are synthetically manufactured.

The very first approved liposomal nanomedicine was **AmBisome** (an altered liposome), which is capable of binding to fungal cell walls, resulting in entry of the nanodrug, disrupting the cell wall thus leading to overaccumulation of lipid in the cytoplasm and killing the cell.
Venofer, another important nanomedicine, is a nanocolloidal solution of iron carbohydrates. It is frequently used in overcoming the toxicity of iron(II) salts which is caused due to ingestion of iron supplementary tablets and syrups without proper dosage (generally cases of children have been witnessed).The regulatory bodies approving the use of such nanomedicines are associations like United States Food and Drug Administration (**FDA**) and European Medicines Agency (**EMA**).They work upon separate norms of usage and manufacture guidelines.

THE MAJOR TASK: TARGET SPECIFICITY

Nanomedicines are extensively used in the specific targeting of the drug based on the tissue or organ level. For example, in Kaposi's sarcoma which is a type of cancer of the lymphatic endothelium, giving rise to blood filled lesions on the affected area of skin -Caelyx/Doxil(a type of liposomal nanomedicine) is used in its treatment, which allows its preferential release at the kaposi's sarcoma lesions, thus reducing general toxicity through permeation and retention effect.
In diseases for example glioblastoma 9 (a brain tumour category), the ability of the nanomeds (polymeric micelles type) to cross the blood brain barrier is potentially applied that targets specifically glial tissues of the nervous system and is an intense, useful process to avoid disease progression. In the treatment of cancer, the beneficial effect of the nanomedicines is production of high level permeation (penetration powerby passive diffusion and carrier accumulation in the region of tumor). Hence nanomedicines can be combined with various mechanisms of drug targeting and

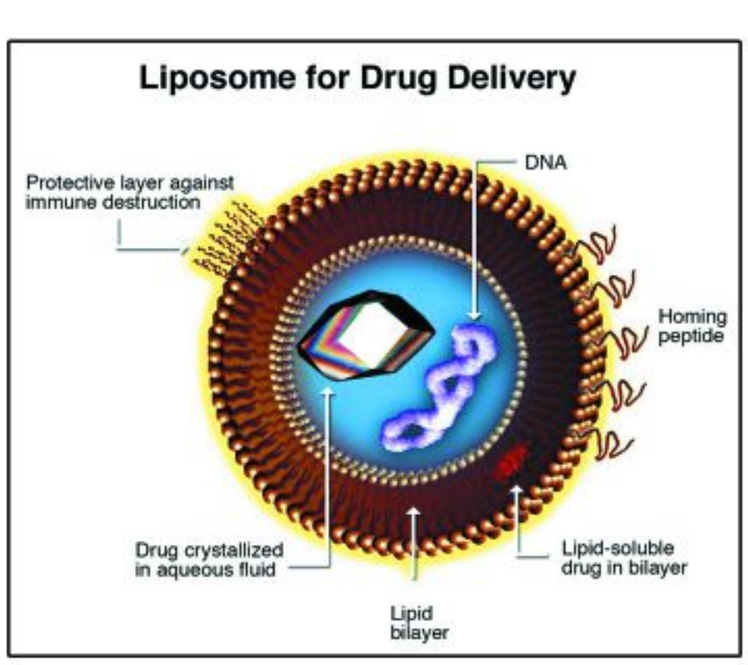


MAJOR TYPES OF NANOMEDICINES

The major advantages of nanomedicines are the scope of reducing side effects by improving pharmacokinetics (PK) (body effects on the drug), pharmacodynamics (PD) (drug effects on the body) and specific targeting (passive/active).The use of such medicines is widely seen as a generic form of a drug that is available to the general public. The therapeutic equivalence (TE) (efficiency of the active substance) of the generic compound is characterized by the pharmaceutical equivalence (PE) (efficiency of similar active substance in the drug) and bioequivalence (BE) (degree of similarity between a generic product and a drug) of the drugs used. In many nano-medicines, the active substance is not a homo-molecular structure but consists of different, closely related nanoparticulate structures that cannot be isolated and quantified completely or described by physicochemical analytical means.

NANOMEDICINE IN CORONARY ARTERY DISEASE

This is a recent research that has been successfully carried out and approved to be published in the Indian heart journal as a review article.Atherosclerosis is a chronic condition where in the arterial wall thickens due to deposition of pf lipoproteins and becomes inflamed as a result of atheromatous plaque formation. This high rate of inflammation in turn causes endothelial injury.Nanoparticle based drug delivery has been tried in preventing the same. Bisphosphonate is a potent inhibitor of macrophages and monocytes, so liposomal nanoparticles encapsulated with bisphosphonate have shown effective penetration in macrophages and monocytes thereby reducing proliferation of those cells, hence decreasing the intensity of inflammation.
Nanomedicines, also play a major part in imaging. For instance, magnetic nanoparticles, ferromagnetic iron oxide particles with poly dispersive properties are being used to accentuate the contrast for MRI. Also, gold nanoparticles due to their strong light scattering properties can be used in optical imaging of the coronary blood vessels and there are several other nanoparticles too that are being put to use in biomedical applications.

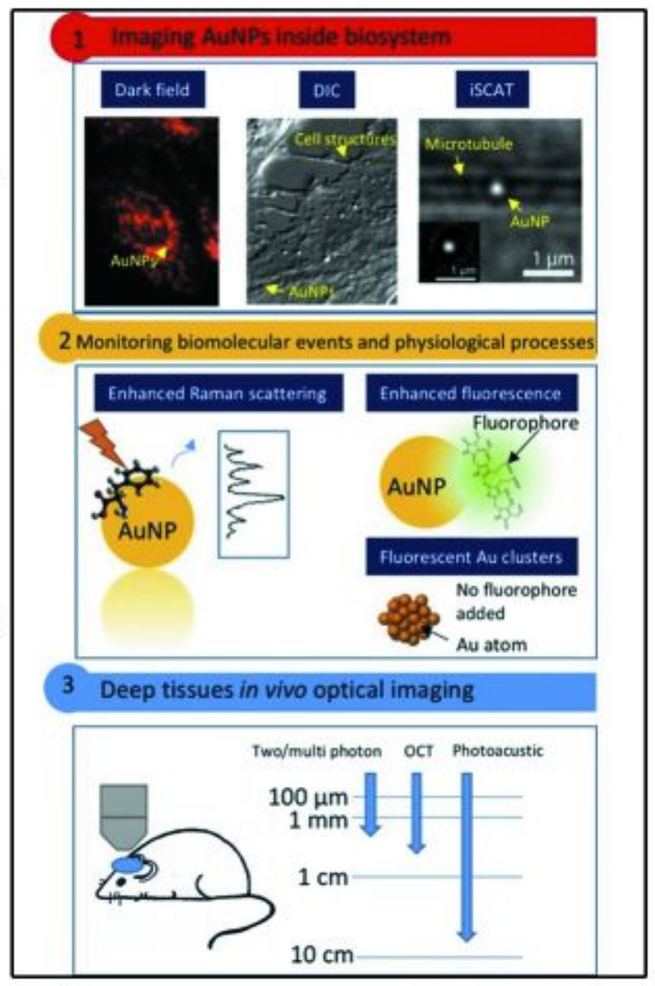


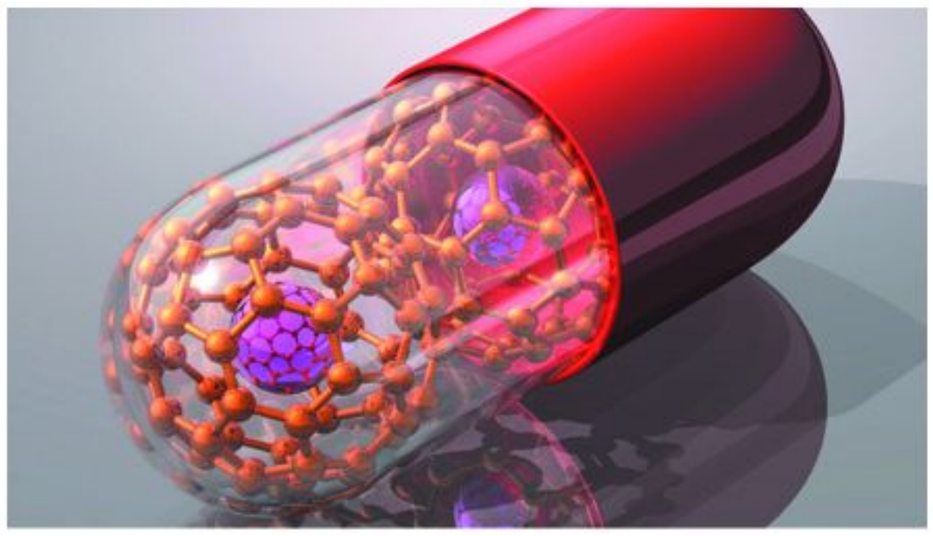
ADVANCEMENTS IN NANOMEDICINES

Since nanomedicines are extensively being tried out in the treatment of various types of cancers (chemotherapy), cardiac problems (pacemakers), insulin pumps, drug delivery systems and several others, these hold essential positions in the development of medicine.

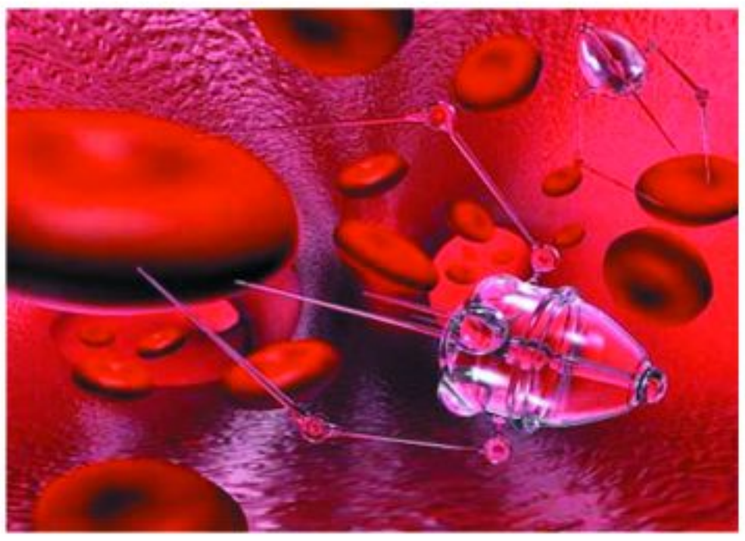
The generic forms of the nanomedicines are termed as the nano-similars, that exhibit similar properties like the nanomedicine in application but slightly differ in the complexity. The nanomedicines and nano-similars have made the process of development and consistency of manufacturing very challenging. This is because the nano similarshave to maintain their similarity to the most possible extent, but with the increasing demand of large production, there remains a lot of flaws in the consistency of the products.

It is important to note that the nano-similars, also referred as follow-on versions of nanomedicines, can be very profoundly altered and examined thus paving ways of development in this field of follow-on products that would be beneficial to the patient.





Nanomeds-a transition in medicine



Unique targeted delivery of substance

Examples of nano-similars are mepact and myocet.

The aim is to substantially use the achievements from basic science and bring them to a patients expectations by evolving the regulatory sciences.

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BIOTERRORISM

-Priyadarshini Mukherji
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"Terrorism has become a festering wound. It is an enemy of humanity." The words of Atal Vihari Bajpayee stand true in today's world. The word terrorism spells doom whenever we come across it. Bioterrorism is a trending form of terrorism in this century. Outbreaks of newly recognized pathogens just enhance the threat of them being used as bioterrorism agents.

Bioterrorism can be simply defined as a planned and deliberate release of bacteria, viruses or other biological agents on a large scale to terrorise a population. Historically, very crude methods such as fecal matter or animal carcasses were used to contaminate water sources. However, now refined, concentrated forms of biological agents like toxins and dried spores are available which are enough to destroy the health of a community. These agents, usually found in nature are enhanced in their ability to cause disease or made resistant to certain medicines so that they are more effective in raising havoc.

Noteworthy cases of bioterrorism can be traced back in history. In 1965, during the IndoPakistan War, there was a case of a typhus outbreak in North-eastern India. India's defense and intelligence outfits were alerted to an outbreak of pneumonic plague – well known in biological warfare – in Surat and Bubonic plague in Beed in 1994, which caused several deaths and sizeable economic loss. In 2001, there was a scare of anthrax in Mantralaya. Even as India tries to prevent terrorist attacks such as the one in Mumbai in November 2008, security experts warn that despite not facing a biological attack so far, , the country must not ignore that threat. By the beginning of World War 1, attempts to weaponize anthrax were tested in animals but were unsuccessful. In September and October 2001, several cases of anthrax broke out in the United States. Letters laced with infectious anthrax were concurrently delivered to news media offices and the U.S Congress, alongside an ambiguously related case in Chile. These letters killed 5 people.

Bioterrorism agents are classified as categories A, B and C-

Category A – These include organisms that have a very high transmittance rate, can result in high mortality rates and have the ability to cause a serious public health impact. They might cause public panic and can pose a threat to national security. These agents/diseases include – anthrax (*Bacillus anthracis*), *Clostridium botulinum* toxin, plague (*Yersinia pestis*), and viral haemorrhagic fevers [filoviruses (e.g. Ebola, Marburg) and arenaviruses (e.g. Lassa, Machupo)].

Category B – These agents are of the second highest priority and are moderately easy to transmit and have low mortality rates and require enhanced disease surveillance. Agents include- brucellosis (*Brucella species*), epsilon toxin of *Clostridium perfringens*, food safety threats (e.g., *Salmonella species, Escherichia coli O157:H7, Shigella*) typhus fever (*Rickettsia prowazekii*), viral encephalitis [alphaviruses (e.g. Venezuelan equine encephalitis, eastern equine encephalitis, western equine encephalitis)], and water safety threats (e.g. *Vibrio cholerae, Cryptosporidium parvum*).

Category C – These are the third highest priority agents which include emerging pathogens which could be engineered to increase its transmittance hence it has a

potential to cause high mortality rate and major health impact. Agents include - emerging infectious diseases such as Nipah virus and Hanta virus, and *Mycobacterium tuberculosis* (multidrug-resistant strains).

The targets of these agents are likely to be major metropolitan cities, big urban projects and districts having international borders. The ways these agents are used for attack varies depending upon the type of agent used. In closed and confined spaces like cinema halls and shopping complexes, aerosol mechanisms are most likely to be used in order to affect a large number of people. Another method could be through the contamination of food and water with toxins and pathogens. The deliberate transport of infected animals, or vectors across a border can also be employed. Some of the modes by which these agents could be delivered include using motor vehicles with sprays, hand pump sprayers, simple objects like books, letters etc.

Significant countermeasures for bioterrorism include-

The US senate passed the 'Bioterrorism Act of 2002' which states that there should be an essential element of national preparedness against bioterrorism and that focus should be on the safety of food, water and other consumables from attack by biological agents and toxins.

Appropriate action should be taken on a national and international level. Interpol held its first "Interpol Global Conference on Preventing Bioterrorism" at its headquarters on 1st and 2nd March 2005. The aim of this conference was to examine the risk of bioterrorism attacks, case studies, prevention of attack and the related legal and political framework. The National Disaster Management Authority (NDMA) has begun preparedness activities, but concedes that more cooperation is needed from companies and communities.

The revised International Health Regulations came into force in India in June 2007. These regulations will help ensure that outbreaks and other public health emergencies of international concern are detected and investigated more rapidly and that collective international action is taken to support affected states to contain the emergency, save lives, and prevent its spread.

Public health authorities must implement surveillance systems to recognize the early manifestations of a biological warfare attack. The system must be timely, sensitive, specific, and practical. The surveillance activity will be centred around some key factors like the occurrence of an epidemic with a similar disease or syndrome, many cases of unexplained diseases or deaths, more severe disease than is usually expected for a specific pathogen or failure to respond to standard therapy, unusual routes of exposure for a pathogen to name a few. It should be followed by verification, immunization, and confirmation. Appropriate prevention and control measures should be initiated.

In India, the Integrated Disease Surveillance Project (IDSP) was introduced in November 2004. It integrates the public sector, private sector, rural and urban health system, and has incorporation of communicable and non-communicable systems (unusual clinical syndromes may be included during public health emergencies). The main role of the hospital-based clinical microbiology laboratory in support of a biothreat, biocrime, or act of bioterrorism is to "raise suspicion" when a targeted agent is suspected in a human specimen. It should be prepared to recognize and respond to a covert event involving the collection, preservation, transport, and testing of human specimens. There are some laboratories in India which have been already linked with National Institute of Communicable Diseases (NACD) like Department of Microbiology, AIIMS (Virology); National Institute of Virology, Pune (viral diseases excluding HIV/polio); Enterovirus Research Centre, Mumbai (polio), etc.

Various commercial tests utilizing biochemical, immunological, nucleic acid, and bioluminescence procedures are currently available to identify biological threats. Newer tests have also been developed to identify such agents using aptamers, biochips, evanescent wave biosensors, cantilevers, living cells, and other innovative technologies.

The need of the future is to create awareness among the public, and doctors to stock pile drugs and vaccines; allocation of separate funds and prepare for the attack beforehand. It is indeed a fact that in today's scenario, India is not immune to acts of bio-terrorism. With more than 10 diseases already gripping Indian Public Health, tackling another infectious emergency simultaneously, is very difficult. Therefore, it is crucial to have a suitable infrastructure and plan of action against the threat of bioterrorism ready, well in advance.

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Psychedelics

-Sanket Gosavi
SYBsc (2018-19)

Psychedelics are a class of hallucinogenic chemicals which alter mood, perception and numerous cognitive processes .The name is derived from the Greek words *psyche* meaning "soul or mind" and *delein* which means "to manifest" which when taken together mean "soul-manifesting". They are also known as psychotomimetics because it is thought that they induce a mental state similar to psychosis in its users.

These chemicals can be classified into two broad categories based on their chemical structures:
1.The Tryptamines which include ergolines such as lysergic acid diethylamide (LSD), psilocybin (magic mushroom), etc. and
2. The Phenethylamines which include mescaline, MDMA (ecstasy), etc.

All psychedelics are structural analogs of serotonin, a neurotransmitter, and produce their effects due to their interaction with the serotonin receptors.

Serotonin receptors and its structure activity relationships

Serotonin (*5-hydroxytryptamine*) is a class of monoamine neurotransmitter. It is one of the oldest signaling molecules and must've first appeared approximately 700-750 million years ago. The serotonin receptor family is the largest family of G-protein coupled neurotransmitter receptor and we have 14 types of serotonin receptors out of which thirteen are G-protein coupled receptors and one is ligandgated ion channel receptor. They play an important role in normal physiology, in development of an organism and its cardiovascular and gastrointestinal functions. They also have a huge impact on aggression, appetite, sex, sleep, mood, cognition and memory.

Studies involving various agonist and antagonist of serotonin receptors show that the 5-HT2A serotonin receptors are very important for the psychoactive effects of hallucinogens. Chemically modifying tyrptamines and phenethylamines give rise to psychoactive chemicals which show differences in their effective dosage, mode of administration, duration of intoxication, and their psychoactive effects as well.
For example:
1. *S-alpha-methyl-5-methoxytryptamine* is an effective hallucinogen at a dosage of 2.4mg, whereas *R-alpha-methyl-5-methoxytryptamine* doesn't give rise to significant effects even at a dosage of 3.0mg.
2. *3,4-dimethoxyphenethylamine* gives rise to stimulating effects similar to caffeine at a dosage of 1500mg.
3. Mescaline (*2,3,5- trimethoxyphenethylamine*) has a much higher psychoactivity in healthy individuals than in people suffering from schizophrenia. However, a similar compound, 2,3,4methoxyphenethylamine is a potent psychoactive for in schizophrenics but does not affect healthy individuals at all.

Clinical relevance

As of now, Johns Hopkins University and the New York University is carrying out psilocybin-assisted psychotherapy in terminal patients. Unfortunately, neither of these studies are published as of yet. However, a preliminary report published by the researchers working at Johns Hopkins University suggests that this therapy is quite ***promising***. Furthermore, these chemicals are also known to have positive impact on people suffering from psychological distress, suicidal

thoughts, depression, alcohol and tobacco addiction, cluster headaches, OCD, etc.

The extrapolated LD50 of LSD is 100mg when administered orally and the usual recreational dosage is around 100-200ug. Other hallucinogens such as mescaline, psilocybin and DMT have similar properties. Due to this, the toxic effect of these chemicals is negligible. For all of these substances, only three reports of human fatality are known till date. Furthermore, animal based models which are used to predict abuse potential of drugs show that these chemicals do not cause dependence or addiction. However, due to legal restrictions and the persisting social stigma surrounding these chemicals, it is difficult for individuals or organizations to study them. Even if psychedelics are finally proven to be inadequate for therapeutic purposes, the only way to achieve a conclusive judgment is through proper clinical research, and based on the data we have right now there is no doubt that these psychoactive chemicals could be very useful and are worth studying.

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Can Bacteria Talk ?

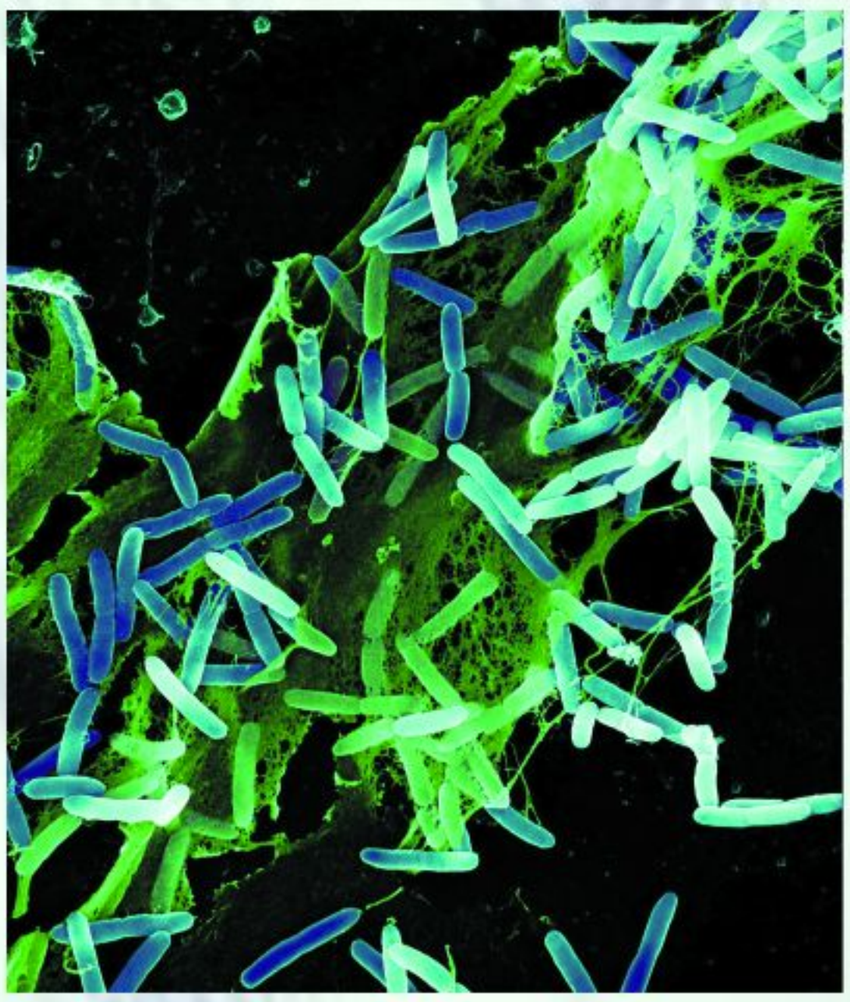
-Freya Cardozo
MSc Part- 1
(2019-20)

So, what do you think, do these little microscopic creatures communicate with each other as we do? If yes, what do you think their language is? These organisms speak the language of chemicals. These little beings have got their secret language and the words they communicate with each other are nothing but molecules called autoinducers and the language is quorum sensing.

Quorum sensing is the bacterium's ability to sense and respond to these autoinducer molecules by regulating certain genes. So how do they do this? The bacteria coordinate their actions. They do this by quantifying their numbers. This is how it works. Bacteria produce autoinducers and secrete them outside the cells. When the number of the bacteria around is less these autoinducers, they just flow away like the screams of a man alone on an island. But as the bacterial population increases, the concentration of autoinducer molecules in the vicinity increases. Thus, through the autoinducer molecules, the bacterium can sense the population of bacteria in its surrounding.

Through the mechanisms of quorum sensing they regulate different activities like planning an attack on you, creating bacterial blankets (biofilms),production of bioluminescence for their symbiont, producing antibiotics and much more.

These autoinducers are basically chemical molecules whose chemistry depends upon the bacteria. These comprise of a diverse array of compounds viz Gram positive organisms produce Autoinducer Peptides(AIP) whereas Gram negative organisms produce Acyl Homoserine Lactones(AHL). To prevent cross-communication the autoinducer molecules secreted are highly specific and



conserved among species and this is done by having different acyl chain lengths (of the AHL), for different species.

Bacteria can talk amongst themselves but what if they want to talk to other groups of bacteria? Just like we have a local language(our mother tongue) & a global language (like English),these bacteria also have a global language which are mediated by molecules called as the autoinducer-2.The autoinducer-1 is an intraspecies language whereas the autoinducer-2 is an interspecies language. Aren't these tiny creatures smart? An example of the bioluminescent bacterium is *A. fischeri* (Quorum sensing was first identified in these) that lives as a mutualistic symbiont in the photophore of the Hawaiian bobtail squid. This particular organism produces the autoinducer1 i.e. Acylated homoserine lactones which regulate the genes required to turn on luciferase. It also produces another signalling molecule a furanosyl borate diester i.e. autoinducer-2 which is recognized by many Gram-positive and negative organisms, which helps in communicating with other groups too.

Through the study and understanding of bacterial communication, it is possible to apply this knowledge, for example in the prevention of biofilm formation. Understanding bacterial communication and signalling can also help in diagnostics. Where the traditional diagnostics can't help; knowing their secret codes can help. Additionally, inhibitors of the autoinducers can be produced such that bacteria would not be able to communicate with each other saving us from their attack. Molecules that mimic autoinducers can also be synthesized which may reduce their communication or even confuse them. There are many things to be studied and discovered so maybe you can be the next to venture into this vast stream of Bacterial Telecommunications.

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Superbugs the Supervillains

-Rahul
MSc Part 1
(2019-20)

WHAT MAKES A BACTERIUM A SUPERBUG?

Bacteria are one of the earliest forms of life (around 3.5 billion years old). They are the masters of survival and can be found almost everywhere. Although a large population of bacteria do not harm human some are capable of causing fatal diseases.
Antibiotics have revolutionized the field of medicine and saved millions of lives. However unrestrained prescriptions and consumption of antibiotics have led to the development of resistance in certain bacteria, to these antibiotics. Bacteria that are resistant to single or multiple groups of antibiotics are termed Superbugs. Overuse of antibiotics has created a selective pressure on bacteria, thus increasing the population of antibiotic-resistant bacteria.

ARE CANCER PATIENTS MORE SUSCEPTIBLE TO SUPERBUG INFECTIONS?

Every year around 700,00 people worldwide die because of superbug infections. There is a higher susceptibility to superbug infections seen in patients suffering from cancer. This is due to the employment of chemotherapy. Chemotherapeutic drugs target the body cells as well as the normal gut flora. This allows the colonization by several pathogens which affect immune cells. Thus the body is left without a healthy intestinal immune system as well as competition through colonization provided by the gut microbiome. This paves a way for multidrug-resistant bacteria to enter into the body. Out of 100 cancer patients,75 patients die because of carbapenem-resistant bacteria. Carbapenem is a broad-spectrum antibiotic that targets pathogens by binding to penicillin-binding proteins which are membrane-bound and cytoplasmic. Abdul Ghafur, one of Indias fiercest anti-superbug campaigners is the author and coordinator of the "Chennai Declaration", which is a document and an initiative to tackle the challenge of antimicrobial resistance in India, say that the cancer patients he sees dying from drug-resistant bacterial infections represent post-antibiotic era - in which something as small as a scratched knee or a cold will kill humans'.

SUPERBUG RELATED INFECTIONS IN INDIA

In the year 2018, India had a confirmed case of a superbug infection which occurred in the city of Vellore, Southern India. Doctors from Christian Medical College found a multidrug-resistant,flesh-eating bacterium - *Klebsiella pneumoniae.* Of the patients suffering from sepsis, 27% were infected with *K.pneumoniae*. As India is a country with a large population, a large percentage of which have inadequate access to allopathic care, there may be dozens of unreported cases.

SUPER BUG found in one of the most remote places on earth - ARTIC.
A metallo-β-lactamase producing superbug first reported in 2008 in India, New Delhi is now found globally. Its resistance to last-resort antibiotic colistin was discovered in 2015. This superbug which was found in the surface water in Delhi has also been found in one of the most isolated places on earth - The Arctic, which is around 8000 km away from New Delhi. A groupof scientists analyzing the soil sample collected from Kongsfjorden, Arctic region of Svalbard,which has less than 120 people living on an entire island, found New DelhiMetallo beta-lactamase 1 protein in the isolate. This study is one of the best examples underlying the transfer of resistance genes across remote geographical distances.

'FIGHTING THE WAR AGAINST SUPERBUGS

A group of researchers from Sichuan University, China have shown that blood coagulation factors 7, 9, 10 hydrolyze lipopolysaccharide of gram-negative bacteria whereas no antibiotic was found to have the same mode of action. These coagulation factors are very much effective against *Pseudomonas aeruginosa, Acinetobacter baumannii* - which are among the listed superbugs by WHO. A cost-effective strategy to increase the production of these blood coagulation factors may serve as a potent weapon against superbugs. Another way in which a superbug can be eliminated is by using tiny killer virus robots called bacteriophage which hold a promising future for the post-antibiotic era against superbugs. Phages kill only certain kinds of bacteria and are so specific that they do not interact with the human cell surfaces. Thus they are best suited for replacement of antibiotics.

Instead of depending largely on antibiotics to cure infection their use should be minimized. The drugs of last resorts should be used only when other options have been exhausted. It is also important to study and understand the transfer of resistance genes across bacterial populations. More people and health care providers are needed to be informed about Antimicrobial stewardship which aims to educate health care providers to follow evidence-based prescribing of drugs. With this collective effort, the overuse of antibiotics is expected to reduce along with improving patient safety and decreasing unnecessary medicine cost. Superbugs which are difficult to eliminate because of their widespread and acquired resistance can be controlled through Antimicrobial stewardship that involves a bundle of interventions to promote and ensure the optimal use of antimicrobial treatment that has a minimal impact on the development of resistance.

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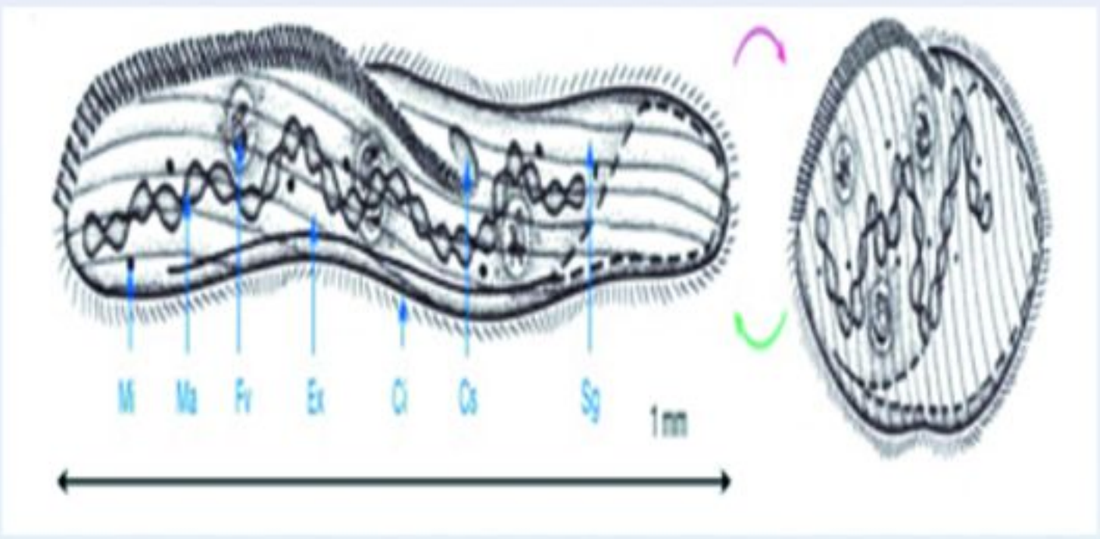
Rediscovering the protist: *Spirostomum ambiguum*

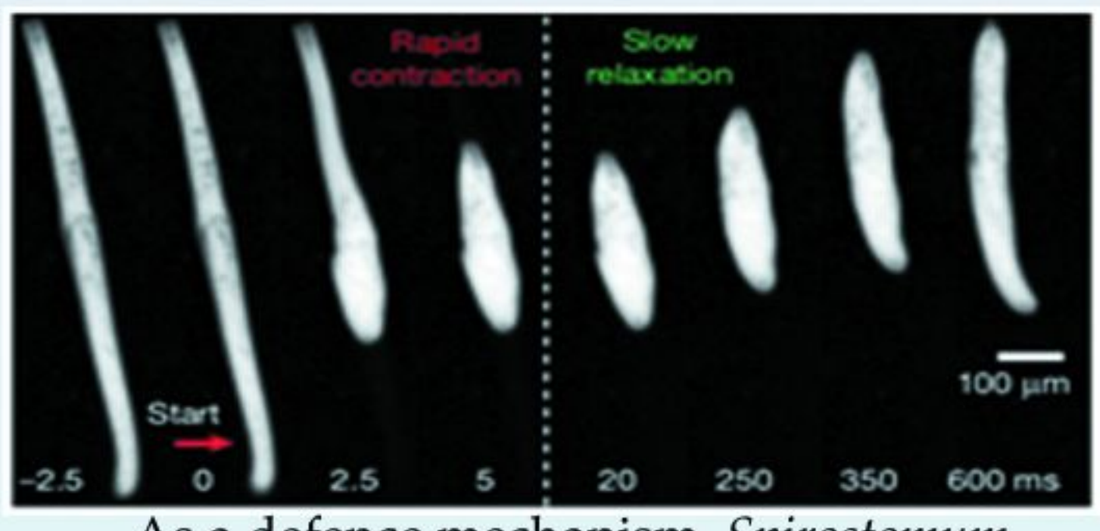
-Jagjyot
FYBsc
(2018-19)

Communication is necessary for a community, whether it is between animals, plants or even single-celled organisms. Communication between single-celled organisms of a community can be concerning the source of nutrition or presence of prey/predator in the surrounding. These signals could be in the form of 'trigger waves' or 'hydrodynamic waves' Action potential generated by neurons, which travel at a speed of 100 meters per second is an excellent example for trigger waves. Trigger waves are signals passed on from one reactant to another in such a way that the speed and the amplitude of the signal doesn't get affected. Signals transmitted as trigger waves travel faster than hydrodynamic waves but trigger waves need a suitable medium like cytoplasm or close contact with the receiver cell. On the other hand, the hydrodynamic waves can mediate long-ranged communications via the motion of fluid in the surrounding. These waves travel long distance but are slow and die with distance and time.

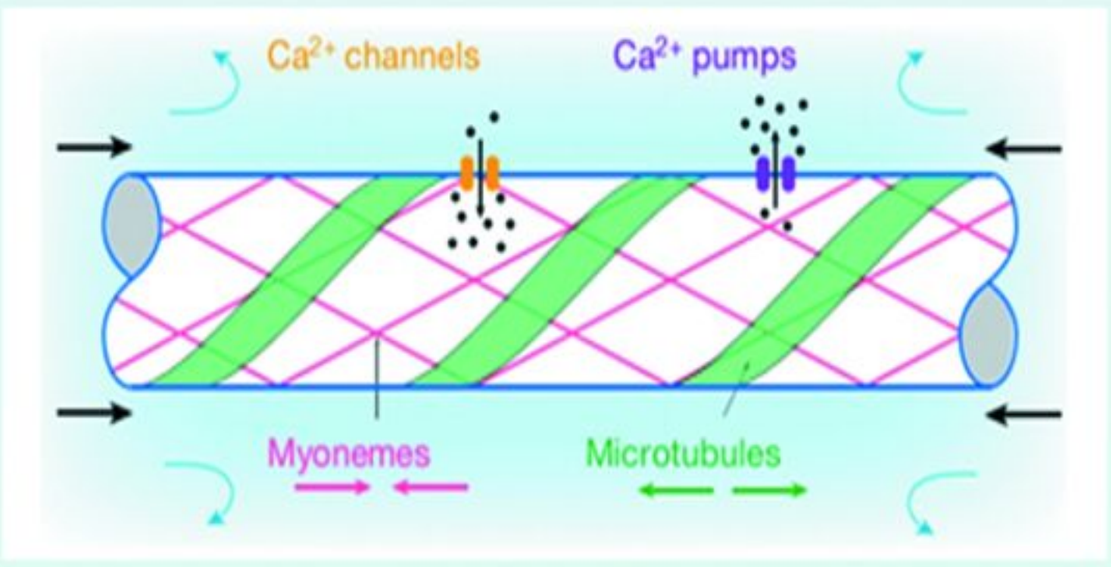
Scientists at Stanford University have discovered a new way of signal transmission in a protist *Spirostomum ambiguum*, which they termed 'hydrodynamic trigger waves'. These signals are transmitted in a chain reaction from one cell to another. Hydrodynamic trigger waves have high speeds of (about 0.25 metres per second) like trigger waves and can travel long distances like hydrodynamic waves.

With a body length of 1.1 ± 0.2 mm, Spirostomum ambiguum is known to be the largest protozoan. Cilia present on the body surface are coordinated in a metachronal wave motion allowing them to swim at a speed of 0.2 mm per second.



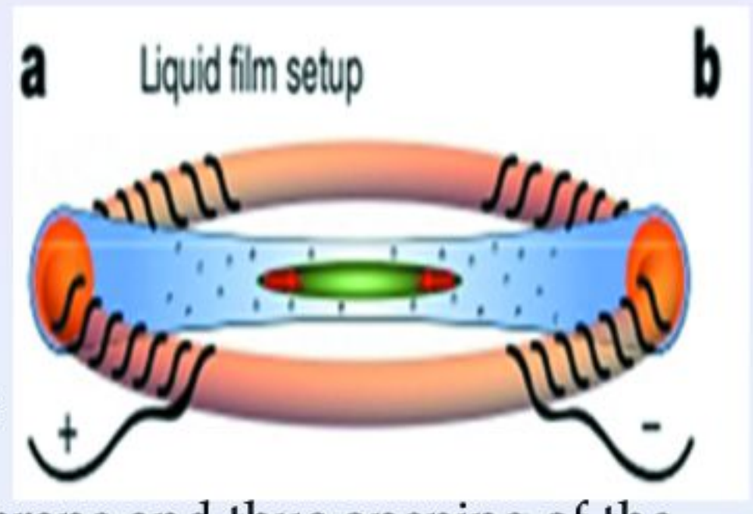


As a defence mechanism, *Spirostomum* contracts its body by 50% within milliseconds and releases toxins. After this, it slowly relaxes into its original length. When observed under the microscope, these protozoans contract so fast that they seem to disappear from the field when a person observes them for the first time.

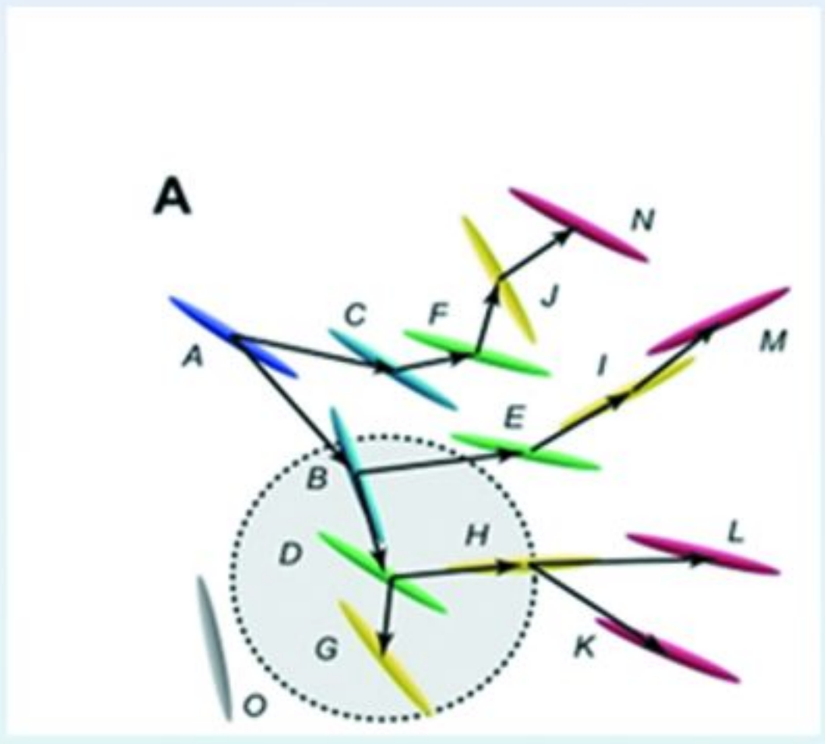


This contraction is regulated by the concentration of Ca2+ inside the cell. Ca2+ concentration is maintained at a very low level by ion pumps when the cell is at rest but when the cell is triggered the Ca2+ concentration is raised to a very high level inside the cell by the ion channels such that these ions bind to the myoneme filament that generates a tensile

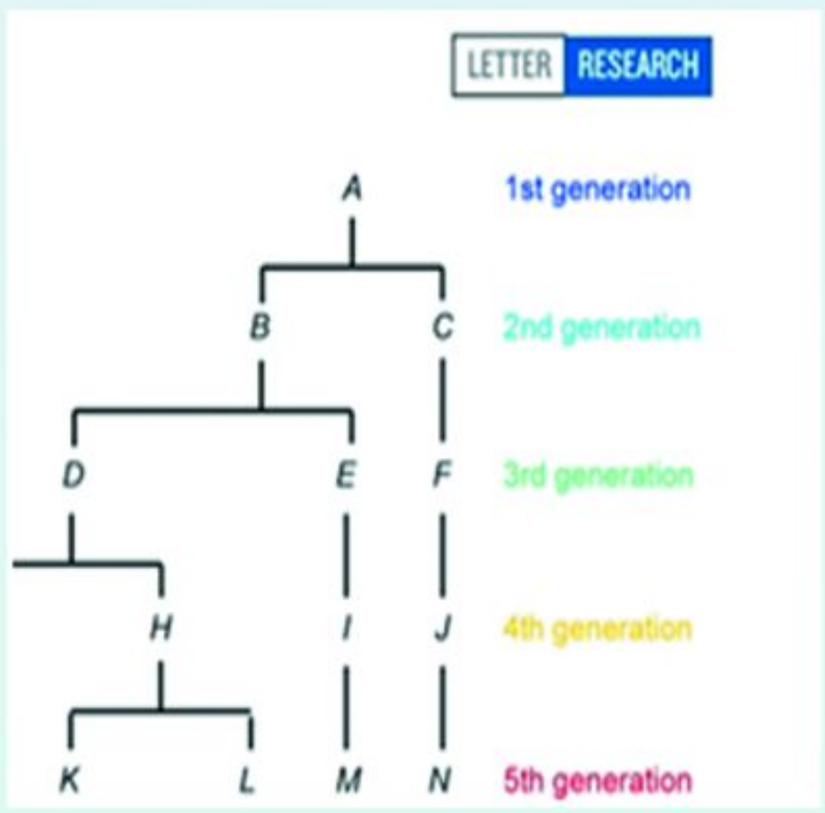
force leading to contraction. Spirostomum can repeat these contractions unlike nematocyst firing (nematocysts are stinging cells present on the tentacles of jellyfish). Due to this capability of *Spirostomum* it becomes an ideal model organism for the study of ultrafast motion in biology.



Liquid film experiments show that long-ranged flows (vortex) are generated around the organism after the contraction and the vortices expand into the medium over time. An individual *Spirostomum* is capable to of displacing particles up to 10% of its length by contraction-relaxation, and this could be used to disband the released toxin and help in food transport. *Spirostomum* detect their prey in their surrounding due to change in the strain rate of the flow of of the moving liquid.This leads to stretching of the cell membrane and thus opening of the mechanosensitive ion channels. As the ion channels open, there is an increase in the intracellular concentration of Ca2+ causing a contraction and release of toxin. To study this flow sensitive opening of ion channels, a microassay was developed.



When present in a group these organisms exhibit a collective phenomenon which is like a chain reaction. When the first organism contracts it generates a vortex that leads to contraction of other organisms. Along with distance, configurations of the receiver organism also matter as these hydrodynamic trigger waves are directional in nature. The hydrodynamic trigger waves are twice as strong along the body axis. Cell density plays a major role in signal transmission. Low densities will lead to fading of the signal and at high density as Einstein viscosity increases the suspension becomes dense due to which more energy will be needed to contract. Below a critical density, the hydrodynamic trigger waves spread radially and reach out the periphery of the colony in large number. Above the critical density, the signal flows in the form of fractals like lightning discharges. Hydrodynamic signals can be used to synchronize activities within a colony as defence against a prey or for nutrient mixing. *Spirostomum* is now intensively studied because of their unique cell communication as they are the only known organism to show this new way of communication. However, similar rapid contraction are observed in many ciliates like *Vorticella* and *Stentor*. The researchers postulate that hydrodynamics trigger waves are universal and are not only limited to *Spirostomum*.



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Events

Hitchhiker's guide to Microbiology Exhibition 2018

The Khandala Seminar

The Khandala Seminar was conducted by the Department of Biotechnology for its students by the Undergraduate Association of Microbiology, as a way for the students and teaching faculty to bond with one another as well as to conduct the annual department review. All professors in attendance—Ms. Miriam Stewart, Ms. Sangeetha Chavan, Dr. Karuna Gokarn—seemed as excited as the students themselves to treat this break from college as an opportunity to de-stress.

Our trip started after lectures, as everyone boarded the bus with glee in their hearts on the afternoon of 19th January 2019, and the students made their joy known as they sang their hearts out during the bus ride. The arrival at St. Xavier's Khandala Villa was fairly late, so everyone was asked to freshen themselves up and convene in the hall for a round of games and fun.

The third-years students made every effort to make their younger counterparts feel at ease and befriend them. The second-years took the initiative to introduce themselves, leading to a generally amicable atmosphere, as everyone departed for dinner, ready for another fun and interactive next day.

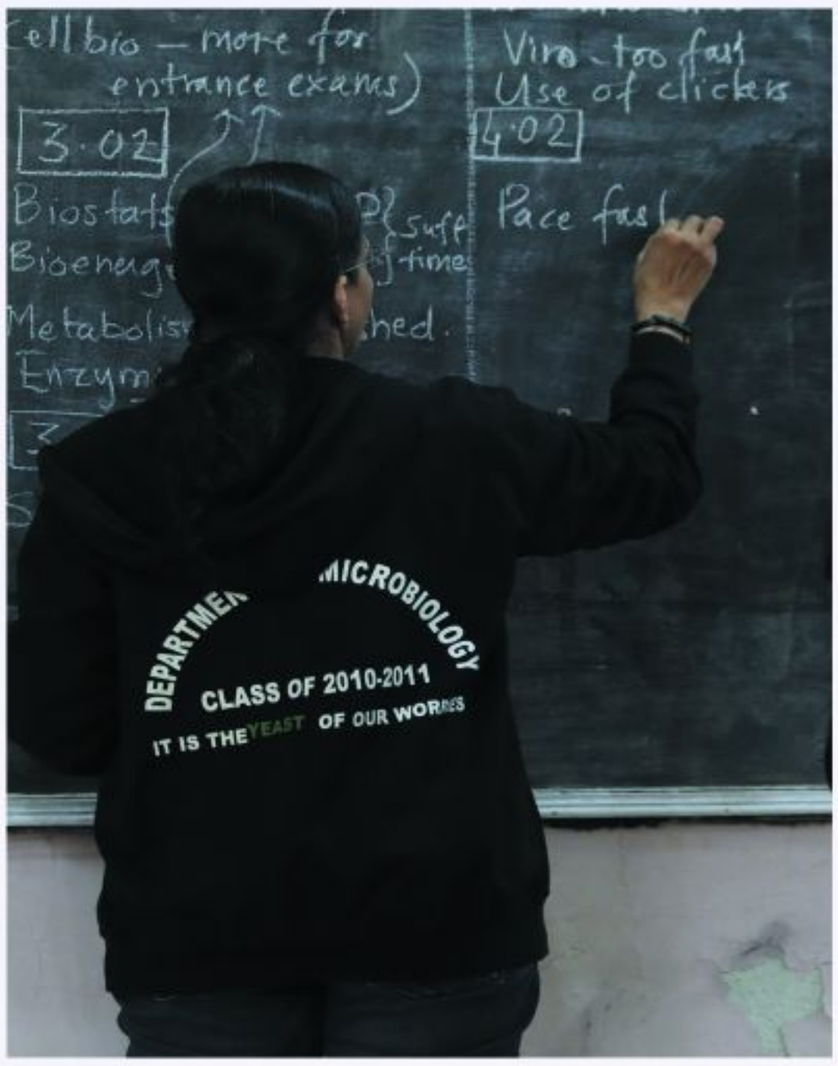
The following morning, some students took a walk around the back of the villa, awed at the beautiful view from the cliffs in the early morning chill. A filling breakfast was followed by the main agenda of the trip: the department evaluation. We were asked to describe, course-by-course, teaching methods followed by each of the teachers to get comprehensive feedback.

The third-years, on the cusp of graduation, were kind enough to talk about the various internships they had done and what they gained from the experience, as well as about what the future held for them here on. The SY's took this as words of advice for their turn in the succeeding year. A break for lunch was followed by the rest of the general discussion held by the teachers, and we were asked to pack up to leave (20th January) sooner than we realised.

All in all, the trip was considered a great success for the teachers and the students, as everyone departed homeward with smiles. It was truly a wonderful break from college and a great opportunity to interact with one another, and having our teachers guide us, even outside of the lab and classroom.

A special thank you to Ms. Miriam Stewart, Ms. Sangeetha Chavan,Dr. Karuna Gokarn, and all the faculty that couldn't make it to Khandala with us.

Khandala Seminar 2018-2019



Panchgani Report

-Riya Jotwani
SYBsc (2018-19)

The industrial visit to Mahabaleshwar and Panchgani was conducted by the Department of Microbiology for its students as a way for the students to get exposed to the various industrial applications where microbiology plays a huge role. It also served as an interactive session for the MSc students to bond with the undergraduate students and help them with different aspects. The professors in attendance- Dr. Pradnya Gogte and Dr. Aparna Talekar took complete charge and were as enthusiastic as the students, which encouraged the students further.

The entire trip encompassed the students visiting three places, namely, the Pure Gold Cheese Factory in Mahabaleshwar, the Mapro Gardens situated in Panchgani and a sugar cane factory in Mahabaleshwar.

In the Pure Gold Cheese factory, the students were shown the entire protocol of industrial cheese making along with different maintenance conditions and the various equipments involved in the same. The students were briefed upon the different types of cheese produced there, along with the microorganisms involved in all types. The lab where those cultures were grown was also shown to the students and they were even allowed to taste some of the different varieties of cheese being produced. There was a bakery store too, where different varieties of cheesecakes were being baked and sold. The Mapro Gardens covered a huge land area and was mainly a commercial space where all of Mapro's leading manufactured products were being sold. At the entrance, they had glass chambers inside which "khakhra production" was being carried out live. Right outside the chambers, there was an arrangement to buy those khakhras. They also had an entire commercially laid out food hall where Mapro products like their fruit squashes, chocolates, jams, jellies, candies and tea extracts were being sold.

The last trip was to a sugar cane factory, where the students got to see each and every step elaborately from raw sugar cane being transported from the fields to their cleaning, crushing, sieving and processing to make molasses, sugar and powdered sugar as the final products. The students were given a proper tour inside the factory, where they even walked through the colossal machines themselves to see the processing steps. Not only this, but also how molasses is used to make other raw products for alcohol fermentation was demonstrated to the students. They saw fermentation tanks where the alcohol was generated and also the distillery where the alcohol was sent for further distillation and purification.

All in all, the industrial visit was a great success for not only the students, but also the teachers, as everyone departed homeward with smiles. It was truly a wonderful experience out in the industrial world for the students to realize the immense potential microbiology as a field contains in all the domains, with special reference to the food industry here.

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Bhandup water treatment plant visit

-Moumita Sengupta
SYBsc (2018-19)

The SYBSc class visited the water treatment plant at Bhandup, accompanied by Dr. Aparna Talekar and Dr. Pradnya Gogte. This plant recovers fresh water from nearby sources and over 20 billion gallons is treated every day. Chlorination takes place in two master balancing reservoirs. The pre chlorinated water first undergoes sedimentation and PAC (polyaluminum chloride) is added at different points of the circulation. The optimum PAC dose is determined by the Jar Test. Too little of it hinders floccule formation and too much generates larger floccules that floaton the surface. The filtration of the water takes place through rapid sand filters. 72 tanks with fine quark sand are present in the plant. A backwash is given every 27 hrs. with clean water. The lab has many qualitative assays done over a specific period of time every day. Post analysis of color and taste, a turbidity check is carried out. For acceptable aluminum levels, spectrophotometric tests are done once per shift. Oxygen and pH probes determine optimum levels of both respectively. The lab conducts bacteriological tests for total coliforms and fecal coliforms by using M-endo agar as a suitable media. A second chlorination is done, after which the water is pumped out for urban supplies.

Zero Waste Campus!

-Jardin Rebello
MSc Part 1
(2019-20)

Today's world is growing, with all the sky scrapers and technological advancements which we can see almost every day, but at what cost? We are giving up on good fertile lands to companies with big names so that they can expand their empire without even giving a second thought on what the after effects could be . On the other hand there are other lands which could be used to create farmlands but then they have converted them into large dumping yards which are just used to dump waste, which is followed up by incinerating this waste, without segregation of the waste into dry and wet waste. Added to this there is a lot of rotting taking place due to which we get foul odour and aerosols are generated, which can cause a lot of diseases in children and in elder people Also, these dump yards are very prone to catch fire even without a spark, this is because of the methanogenic bacteria which produce methane along with a lot of heat due to their active metabolism due to which the junkyard catches fire! 1, 2 & 3 poof, a wildfire is spread. My main focus in this article is to provide a good solution (if not a foolproof one) in the name of Composting!

Composting is nothing but a simple process that recycles various organic materials, otherwise regarded as waste, and produces a soil conditioner which is rich in nutrients. A compost is just like your ready-to-eat foods which don't require you to do a lot of effort, it just requires a bin and addition of the biodegradable wastes that you generate in your daily life. Some examples of biodegradable wastes that a personal usually generates,are food waste (leftovers, fruit peels, etc), paper (tissue papers, paper soiled with food items), hair, etc. In addition to this, these wastes should be mixed properly with Coconut powder i.e. cocopeat/ sawdust (these are used to remove all the moisture from the waste and make it dry, since dry biodegradable waste degrades faster than wet wastes. Done! Your work with this is completed. Now you would require to allow this mixture to stand for a interval of a few days or a week, cocopeat/ sawdust should be added periodically until the waste is completely degraded. If at all this mixture starts to stink, buttermilk could be used since it reduces the foul odour. Once degraded, this could be used a soul conditioner to make the soil more fertile rather than dumping the wastes in a normal bin which would otherwise land in one of the dumping grounds. Department of Microbiology of St. Xavier's College, Fort, Mumbai practices this to achieve a ZERO WASTE CAMPUS, by asking their students to throw wastes into their respective bins i.e. biodegradable into green bins and the rest in the red bin. This primary segregation makes work easy for the later step which includes transfer of the waste into the compost directly, however, due to lack of awareness amongst people or ignorance to environmental issues, people cannot practice such things, which is the sad part.

As we can see the benefits of composting over dumping grounds, composting should be a method that should be used over dumping creating a cleaner environment. Also the product obtained can be used for making a greener environment.

A few other activities of the ZERO WASTE CAMPUS project are :-

1) To collect MLP (multi layered packaging plastics) which is taken by Safai bank people and given to ACC cement factory where it is burnt at a very high temperature and hence reduces toxic emissions. If dumped at Deonar dumping ground, it is burnt at a very low heat and hence releases harmful toxic emissions. For more information please visit, https://safaibank.org/.

2) To collect Plastic and give them to Project Mumbai, this organization organizes Plastic collection drives and sends them for recycling & make benches, bins (given to housing societies that donate the most amount of plastic), T-shirts and compass boxes (gifted to school children). For more information visit:- https://projectmumbai.org/.

Internship Reports
(SYBsc 2018-19)

I interned at the Lilavati Hospital where I worked in the Microbiology lab, Biochemistry lab and the blood bank.

Microbiologylab

The lab mostly received sputum, urine, blood and occasionally CSF samples. Each of the samples are processed in a different way with different media for isolation. Bacterial samples undergo gram staining whereas the fungal sample undergo KOH staining. Post isolation and staining, depending on the requirements sent by the doctor; the sample may also undergo antibiotic susceptibility testing. Extended antibiotic testing towards Ertapenem, Imipenum and Meropenem antibiotics was also carried out.BacTAlert was used to check for microbial growth in blood samples, GeneXpert to amplify the nucleic acid which assisted in identification of various organisms. A saline suspension of the organism with a specific OD was loaded onto the specific card based on morphological characteristics. The cards with pre-loaded biochemicals would then identify the organisms with the help of a computer.

In serology, different rapid tests were performed to detect different diseases. VDRL (Veneral Disease Research Laboratory) test done for diseases like syphilis. This included Rapid Plasma Reagin Card Test; which is based on flocculation dueto antigen-antibody interactions can be visually checked. ELISA used for detection of various diseases like dengue. There was a separate room for processing TB samples with Lowenstein-Jensen Medium used as a selective media for Mycobacterium species. These produce buff-rough-tough growth. Ziehl Nelson staining is done for these organisms which is an acid-fast staining technique using malachite green/methylene blue as counter stain.

Biochemistry lab

In the Biochemistry lab I learnt the various techniques used for the estimation of biochemicals including vitamins, hormones and other enzymes. RIA (Radioimmunoassay)is used primarily for estimation because of its high sensitivity while Gel electrophoresis is used in the estimation of immunoglobulin and proteins. Other tests done were- HIV Tri-DOT, estimation of Magnesium, calcium, iron, sodium, chloride etc.

BloodBank

I learnt the full procedure of blood collection and storage, tests done to check donor's blood and for diseases like malaria and syphilis, the technique used to estimate hemoglobin.Cross matching, Direct Coombs test, Indirect Coombs test (indirect anti-globulin test) are some of the key tests that are done using Column Gel Agglutination systems.

-Subhashri Acharya

During my summer in 2019, I worked under Dr. Carolyn Norris at Johns Hopkins University,Baltimore for about 5 weeks. During this period, I worked on CRISPR construction and genome engineering of the worm, *Caenorhabditis elegans*. I worked in the Developmental Genetics Lab and carried out mutations in the genome of the worm using CRISPR- Cas9 to cause a switch from the non-roller phenotype to a roller phenotype (helically twisted). During my time there, I learnt a lot about the model organism and its usage in genome engineering from the previous literature provided by Jennifer Doudna. Further, these worms were isolated,and its desired gene sequence was amplified using PCR. It was run on the gel to cause a mutation such as a roller worm could be produced, we followed the CRISPR- Cas9 technique by inserting the CRISPR construct along with a

co-injection marker. It was a rather intriguing internship as I worked on isolating single typed worms using PCR and gel electrophoresis as well as inserting CRISPR constructs in its genome. This internship made me realise that the basic techniques are highly necessary at each step and one builds upon these. Apart from this, the work done in these five weeks was quite overwhelming and opened multiple avenues for me.

-Ishita Dewan

I interned at Swati Spentose Pvt. Ltd., Mumbai pharmaceutical company. Swati Spentose serves the pharmaceutical field by producing polysaccharides, steroids, hormones, veterinary, lifestyle and critical drugs since the last 40 years.

My first project at the company was to assess their effluent treatment plant (ETP) in Vapi and studied the effluent treatment plant. I got the COD (Carbon Oxygen Demand) and BOD (Biochemical Oxygen Demand) measured at various stages of the treatment process and found them to be satisfactory. Subsequently I sought to enquire about the more advanced forms of ETPs installed by other manufacturing plants and found out that a neighbouring company had outsourced its ETP from an Italian company, Hydrotech Engineering. Since this was more automated, there were lesser chances of contamination. My presentation of these conclusions at the head office was a huge success for the company.

Pyridine is a chemical compound required in the production of one of the company's most important formulations- Pentosan Polysaccharide. However, it was very difficult to recycle pyridine as it forms a complex mixture with water which cannot be separated by normal fractional distillation. This was highly problematic for the company as it led to inadequate detoxification of water meant for discharge and made the process less economical, as pyridine could not be recycled After reading a bit on the technologies, I zeroed down on two promising approaches that could potentially solve the company's issue. One was a more advanced form of fractional distillation and the other was a membrane-based separation process known as pervaporation. Further I shortlisted two companies supplying these technologies Pervatech (in Netherlands) and Sulzer (in Switzerland) after which the company set a workable technical agreement with Sulzer.

Another project that I worked on simultaneously involved negotiation with the Explosives Department, which had set up laws mandating the instalment of a solvent storage area of requisite dimensions in a manufacturing plant. The company was planning on setting up a new manufacturing plant and the establishment of the solvent storage area would prove to be expensive, both in terms of money and area. I successfully negotiated with the govt officials from Explosives Department to let us use the solvent storage area from our existing manufacturing plant placed in a neighbouring locality and grant us clearance on this basis.

-Mohit Gupta

Sky Gourmet is an airline catering agency, managed by the Gate Group. Their aim is to provide healthy, hygienic and good quality food to their customers. Our role in the company was as an intern in the Quality Assurance (hereafter, QA) lab. The role of the QA manager is to monitor the quality of the incoming goods, handling, storage, cooking standards, and packaging. The QA manager also handles the complaints received and carries out further investigation on it.

Our work there was to daily assess the quality of the milk, cream, and paneer; water quality and temperature checks. Milk - standard and toned, cream and paneer were checked for its fat content. Water from different water stations is checked thrice a day for its hardness, TDS, chlorinity, and pH. These reports are daily recorded and if there is any error found the samples are either rejected or remedial actions are implemented, in case of water quality and temperature. Temperature and CO levels of various departmental areas, such as the stores, receiving, kitchen, etc.; deep freezers and chillers are monitored once daily and if any glitch is

found, it is reported, and remedial actions are implemented. Sky Gourmet is a food catering agency and it does take care to keep the microbial counts in the food prepared, as low as possible along with taking care of not allowing the contamination of the same by harmful pathogens. Monthly around 120 food samples and 10 water samples are checked for their microbial population. The presence of *E. coli* in less than 103 cells was considered to be safe. But, the presence of *Salmonella spp., S.aureusin* the food sample was unsafe and detailed investigation of the matter was carried out to find the source of contamination. The media used for was Tryptone Soy agar as a general-purpose agar, Braid Parker for *S. aureus*, MacConkey for coliforms and BGLB for *E. coli*. The results for the former three are obtained after 48 hours of incubation while for *E. coli* the results are obtained after 24 hours. The lab also checks the gluten content of wheat flour and atta. This process takes six hours, but it is an essential test as gluten is an allergen and its presence in food can cause adverse reactions in allergic consumers.
During our tenure there, we learnd various skills such as testing the fat content of any dairy products, water testing, microbial analysis of cooked foodstuff, calibration of instruments, CCP's and SOP's in the food industry, HACCP, media preparation, handling the autoclave, drafting monthly reports and investigating any complaint that is received and also about the storage of raw materials and its arrangement in the store, the FIFO concept.

-Maria D'costa, Shruti Murmu, Kreena Nagda

During my tenure at Amity University Rajasthan, I explored the fundamentals of nanotechnology, nanomedicine and nanotoxicology by learning how to critically read papers and design experiments based on the literature review. Furthermore, besides good laboratory practices I was exposed to Occupational Safety and Health Administration and Material Safety Data Sheet, which are essential for carrying out experiments related to nanoparticles. The essential washing of the glassware with aqua-regia was studied rigorously, which is required for synthesizing metallic nanoparticles with desired properties. In terms of laboratory work, I prepared gold nanoparticles with Artemisia plant extracts. Artemisinin, a compound extracted from the plant is used as an anti-malarial formulation, including to treat against the chloroquine resistant *Plasmodium falciparum*. Gold nanoparticles have many medical applications because of their noble metal properties. Antimicrobial activity using various techniques such as pour plate, spread plate, broth dilution, and disk diffusion against Gram-positive (*Enterococcus faecalis*) and Gram-negative bacteria (*Escherichia coli*) were also carried out and results were analysed to select the optimum technique which can show consistent results when performed in the future.
The world of material science is witnessing a revolution in the exploration of matter at very small scale. The varied materials in nano-dimensions find immense applications in the fields of medicine, environment, food and agriculture. Therefore, it is important to learn basics of this emerging field.

-Maitri Khemka

Serum Institute of India Pvt. Ltd manufactures immunobiological drugs and is the world's largest producer of vaccines by number of doses produced. A biologic is any pharmaceutical drug product manufactured/extracted from or semi-synthesized from a biological source. It includes vaccines, blood components, recombinant therapeutic proteins etc. A biosimilar as the name implies, is a biologic that is similar to another biologic medicine which is already licensed. They are created in living cells and require significant expertise and state of the art expertise in manufacturing. Biosimilar monoclonal antibodies are large complex glycoproteins used in treatment of diseases like cancer, rheumatoid arthritis etc. Analytics is an important factor in biosimilar monoclonal antibody development and is used to demonstrate comparability between the biosimilar to the originator and are also used to

establish critical quality attributes of a biosimilar molecule. For example, Glycosylation is a post translational modification that can affect protein stability, half life in serum immunogenicity etc. This process can be altered due to upstream processing changes like Ph, temperature, feeding etc Thus, it is a critical quality attribute that should be monitored.

During the month of May 2019, I interned in the research and development labs of biosimilar monoclonal antibodies at Serum Institute of India, under the guidance of Amar Shrivastav, PhD. This laboptimized biosimilar monoclonal antibody production. Here, I learned to culture transfected Chinese Hamster Ovary cells that were used for antibody production, and monitor post-translational modifications that make the antibodies bioactive and compatible with human biology. Through this experience I was able to apply concepts learned during an honours course in animal cell culture. I learned to design media and feed screening experiments and work with analytical instruments like the Cedex HiRes analyser, Cedex Bio Analyzer, Osmometer etc. My work also involved making interpretations from observations on metabolic products, cell viability and measurement of antibody titre. This helped hone my skills of data interpretation and troubleshooting and taught me to work independently with techniques like affinity chromatography, UV spectrophotometry, HPLC, and glycan profile analysis.

I have also interned in the biotechnology department of the Institute of Chemical Technology from June- October 2018 under the guidance of Shamlan Reshamwala, PhD. I worked on a project involving the culturing of methanotrophs. During my time there, I learned techniques like anaerobic culturing of bacteria, running an anaerobic digester and also practised skills like bacterial transformations and isolations.

-Mathew Salazar

CSIR-National Botanical Research Institute, Plant Gene Expression lab
Guide - Dr. Prabodh K. Trivedi, FNASc, FNAAS,
Senior Principal Scientist

I worked on "Screening of *Arabidopsis thaliana* mutants developed through the CRISPR/Cas9 system". I was involved in learning several techniques in molecular biology such as PCR, gene cloning, plasmid, DNA and RNA isolation, cDNA synthesis, restriction digestion, agarose gel electrophoresis, and histochemical GUS assay.

I studied the life cycle of *Arabidopsis thaliana* and handled it at various stages of its growth. Besides maintaining the plants in the growth chambers, I performed transformations on *Escherichia coli* and *Agrobacterium tumefaciens*, introducing our desired gene to the plant at the end via infection of *A.tumefaciens*. The desired gene could be a marker gene like beta-galactosidase which helped in visualising the uptake, or it could be a CRISPR element which helped in reducing the expression of certain protein intermediates of the phenylpropanoid pathway. These intermediates could be knocked down or their expression could be increased. This was done to elucidate their function in the plant as a whole and to increase the production of desired plant metabolites such as flavonoids.

-Anshit Singh

I worked in Reliance Industries Ltd. for a period of one and a half months under the guidance of Mr. Akshay Chawande. I was working in the Molecular Biology lab. My basic project was based on transformation of *E. coli* genes into various algal strains to provide gene products like Ethanol, nanocellulose and leather. This was done by extracting the genes of interest from E. coli, amplifying and transforming them in algal strains and later, use an expression vector for the same purpose to check for yield.I was given a hands-on to various techniques starting from AGE and PAGE to PCR, plasmid extraction, gDNA extraction, restriction digestion and transformation. A dry lab session included an hour of vector map studies every day. I was taught how to design primers and estimate the *Tm*. I was also

given the liberty to check for and select the desired restriction enzymes for my vectors and host. Weekly lab meetings were held where not only were results discussed, but all safety measures were revised. One of the greatest advantages of working in a corporate lab was the fact that I had almost all the instruments and materials at my disposal. Also, a tour to all the other labs is provided. Everyone was approachable and they all helped me as and when required. The interns had a session with the Quality Control Head where they were made familiar with the basic suit work with regards to QC and also guided on this career prospect. IPR sessions happened once every month.
Overall, it was a good experience. It helped me choose this field for my master'sas I realized I was hugely interested in it.

-Moumita Sengupta

(i) During the second semester of my BSc course, I interned at the Institute of Chemical Technology, Matunga, Mumbai and contributed towards the following projects:
a. "Isolation of methanotrophs from paddy fields and municipal dumping grounds": My role in this project was to identify potential niches to isolate and collect samples. which were further enriched by growing on media with methane as the sole carbon source. I was also responsible for maintaining an anaerobic bio-digester to produce methane for experimental use. A 2-litre anaerobic fermenter was set up and stabilized.During this period, I developed many laboratory skills, such as setting up and stabilizing anaerobic digesters, handling anaerobic microorganisms, and daily data collection and data maintenance for reporting the condition of the digester which required analysing pH, volatile fatty acid (VFA) content and gas composition using GC-TCD. Also, I regularly carried out tests like BOD and COD to determine the working condition of the digester. The VFA/alkalinity ratio was estimated daily to determine the amount and frequency of substrate to be added to the digester.
b. "Conversion of sugar alcohols to biofuels": This project involved the chemical conversion of sugar alcohols to hydrocarbons. My role in this project was to set up and maintain the experimental set up and to calculate the ratio of chemicals required to bring about the reaction. I worked with commercially available standards to determine optimal reaction conditions and validated the optimal reaction using fermentation broth containing sugar alcohols. The laboratory skills that I developed working on this project were setting up chemical reactions, solvent extraction and using GC-MS for analysing chemical composition and structure.
(ii) During the third semester of my BSc course, I was a student team member of the Institute of Chemical Technology's iGEM 2018 team.International Genetically Engineered Machine, or iGEM, is an annual synthetic biology competition. As a team member, my role was to carry out laboratory work and to constructthe planned genetic amplifier circuit by identifying, isolating and testing various genetic components. We also tried to reach out to the general population to explain what synthetic biology is and how it can bring about a change in our society. Our project work was under the "Environmental Track" titled "Smart Soil: Rooting for Sustainable Agriculture", for which the team was awarded a bronze medal. The project involved exploiting the natural phenomenon where plant root exudates act as molecular signals to the soil microflora. The exudate profile secreted by each plant is unique. We aimed to engineer microbes to respond to specific plants by picking up cues based on the exudates secreted by the roots. The test organism selected was Bacillus subtilis. The organism was grown in the presence of plant root exudates of staple Indian crops, viz., rice, wheat, soybean and tomato. The mRNA from these bacteria was extracted for transcriptome analysis to identify genes that are differentially regulated in the presence of the root exudates. Further information about the work carried out is available on the team's wiki page: http://2018.igem.org/Team:ICT-Mumbai

-Marwan Malik

MICROBIOLOGY DEPARTMENT 2018-2019

The new academic year began with a Faculty meeting to plan the activities for the year 2018-2019. At the Graduation Ceremonies all our high performing MSc and BSc achievers of 2017-2018 received their certificates. Ms. Shivani Nandha ranked first among all the post graduates in college with a CGPA of 3.94 of 4 and Ms. Bibakya Saikia ranked 4th amongst all Science graduates and first amongst Microbiology graduates with a CGPA of 3.91 of 4.

Dr.Karuna Gokarn was appointed as an Honorary Consultant – Research Scientist in the department of Microbiology at Sir HN Medical Research Centre (Sir HNHRC) and at Sir HN Medical Research Society (Sir HNMRS)in July 2018 and DBT Star Programme Co-ordinate of the College in September 2018. She is recognized as a Ph.D. guide in Microbiology at Sir HN Hospital and Research Centre from University of Mumbai .

Ms. Pradnya Gogte was conferred the Doctor of Philosophy (Ph. D.) by the University of Mumbai for her thesis titled 'Characterization and Optimization of *Polybetahydroxybutyrate* production by microbial isolate obtained from soil' under the guidance of Dr. (Mrs.) Varsha K. Vaidya from The Institute of Science, Mumbai at the Convocation held on 11th January, 2019.

Graduates 2018

79% of our students got admission into postgraduate courses like the ERASMUS MUNDUS LIVE, Masters in vaccinology, UA Barcelona,UAntwerp, UCB Lyon, National Brain Research Centre, Gurgaon, Vels University (VISTAS), Chennai, National Institute of Virology ,Pune, Xavier Institute of Management, Bhubaneshwar, M.S. University Baroda, Vellore Institute of Technology, Mumbai University, Manipal University,Pondicherry University, Missouri State University, IIT Kharagpur . Others are employed or interning at an organization.

Postgraduates 2018

35% have obtained employment in Industry, 5% are Research Assistants, 50% are studying for competitive exams like UGC-CSIR and three student cleared UGC- (NET)CSIR exam for Ph.D , 10% of students have been employed as Assistant professors.

Student Activities and Achievements

A. Being sociallyresponsible:The SYBSc students checked the potability of 10 drinking water points in the college every month starting from June,2018 throughout the academic year, far exceeding their 5 hours of SIP hours.

B. Peer learning: SYBSc students welcomed the new FYBSc batch with an exhibition entitled 'THE HITCHHIKER'S GUIDE TO MICROBIOLOGY on the 6th and 7th of August, 2018. The Exhibition was inaugurated by Dr. Vivien Amonkar, former head of department. Students learnt from each other about the various aspects of Microbiology and its scope. Other interested Junior, Senior college students and faculty also visited the exhibition which creates bonding, teaches team work, boosts confidence and self-worth amongst students. We also welcomed 15 students from Lord Harris UPMS, BMC school along with their Principal. All

concepts were explained in Marathi, this was a new experience for our students.

C. Organising and Attending Talks and Seminars: Students helped in the organization of talks, workshops and seminars and attended them:

Talks and Workshops conducted by the department:

- IPR lecture was organized by Mrs. Stewart along with PLEA a Programme for Legal Education Awareness which was started by our alumus Mr. Roger Mendonca. Lecture was organized on the 7th of July, 2018 and the speaker was well-known IPR lawyer Mr Janaksinh Jhala spoke on 'Is Patent Law right for me?'. The lecture was thrown open to the students of Biological sciences. About 50 Students and Faculty were present for the talks.
- On the 10th of January in the Microbiology Laboratory, our Alumni Dr. Ritwick Sawarkar and Dr Foster Gonsalves, who came for the Xavier's Conference on Translational Medicine spoke to the students on their work.
- Dr. Nithya John, Senior Trainer, Skill and Knowledge Management, Cactus Communications, Mumbai was invited by Dr. Gokarn to conduct sessions for our SYBSc students as part of Scientific Communication Skills on Structure of a manuscript (IMRAD) and common structural errors and also common language errors in manuscripts.
- A one day workshop on Academic Writing And Popular Science writing was conducted on the 6th of February, 2019 for all M.Sc part - I students who interacted with the resource team from Cactus Communications, Mumbai.
- A career guidance talk was organized by the Department of Microbiology with an aim to divulge information about career opportunities in scientific writing leading to placements by CACTUS Communications, Mumbai. The talk was held on the 23rd of February, 2019 and was attended by 25 MSc and TYBSc students.

D. UMAX (Undergraduate Microbiology Association of Xavier's):
Organized the refreshments for the Annual Exhibition, fun activities at the Khandala seminar, and the Farewell for our MSc and TYBSc students.

E. Honours programme: co-ordinated by Dr Pampi Chakraborty

CLASS ACTIVITY
FYBSc
-Workshop on Antimicrobial effects of Indian plants, herbs and spices for 2 credits
-Microbiology in everyday life for non Biology students for 1 credit
SYBSc Project
Study of cytotoxicity of chemicals using animal tissue for 2 credits
TYBSc
Lecture series-IPR for 1 credit

F. Department Magazine 'The Michronicle17-18': Our annual magazine was compiled by a team of 10 very enthusiastic TYBSc students lead very ably by Editor-in-Chief Ishita Bapna. The team was able to obtain 26 articles from present students and from alumni. 40 copies of the magazine were printed which was with funds from DBT Star17 grant of Rs. 8520/- and UMAX of Rs 7220/-.

G. Educational visits and Khandala seminar:
- 10 TYBSc students were invited to the Open day to ACTREC , Kharghar, on 6th Dec, 18.
- On the 19th and 20th of January a Khandala trip to the Xaviers villa was organized by Ms. Stewart for the Evaluation of the Department and sharing by TYBSc students about their Internships. The 27 SYBSc and 19 TYBSc students attended.
- A trip to Wai and Panchgani was organized by Dr. Karuna Gokarn for 46 UG and PG students who were accompanied by Dr. Aparna Talekar and Dr. Pradnya Gogte. They visited Golden Cheese Factory in Panchgani. on 8th February and Kisanveer Shakari Sakhar Karkhana, a sugar and Ethanol industry in Wai on the 9th of February .
- Four of our FYBSc students Sarah Thomas, Jyoti, Aakasha Mishra and Julia Justin were invited for the National Science Day at BARC on the 27th February, 2019.
- Ms Sangeetha Chavan accompanied MSc part II students for a visit to CETP, Koparkhairane on 4th April 2019

H. The TYBSc and MSc II farewell:
Hosted by the UMAX, First, Second Years and MSc I students on the 23 rd of February in the Fell's Gymnasium. The theme was 'Casino Royale'. Students and faculty alike dressed up for the occassion. There was a feeling of togetherness and plenty of laughter especially due to Stacy's stand-up comedy.The highlight of the event was a dance performance by the faculty. The entire event was organized by the UMAX committee with help from the FYs, Sys and MSc 1.

I. The BOS met on the 9 th of March. Changes in the MSc theory for the syllabus of Semesters 1and 2 were discussed and a resolution was passed to adopt them.

J. The Department under the leadership of Faculty member Sangeetha Chavan continued the herculean task of Solid waste management of canteen wastewith the MSc 2 students roped in to manage the Compose pit in our college with help from the under graduate students. Ms. Chavan also continued her cleanliness drive in the canteen with determination to succeed. She took the help of our undergraduate and postgraduate students who put up posters on how to segregate plastic waste and food waste to be composted.

Student Achievements and Awards

 Internships: Most of our SY and a few of our FYBSc and TYBSc students worked on an internship in the winter and summer vacations. Several students were chosen on an All India Level and Globally for prestigious internships during the months of April, May and June 2019:

*Saanjbati Adhikari, TYBSc, continued her JNCASR POBE – 2017,fellowship program in Jakkur

*Ishita Bapna TYBSc, did a Summer Research Fellowship in JNCASR in Jakkur.

*Maitri Khemka, SYBSc, obtained an IAS Research Fellowship at the Biotechnology Dept in Amity University,Jaipur under Prof SL Kothari

*Shivani Dharmadhikari was selected for a Life Science JNCASR Fellowship with Dr Balasubramanyam, MDRF, Chennai

*Ishita Dewan, obtained an internship at the Johns Hopkins University, USA.

Research Projects: Every SYBSc, TYBSc and MSc Part 2 student participated in project activity.

SYBSc Individual Projects:
37 students working in pairs isolated and identified an organism from the soil Rhizosphere habitat and researched an application. The projects were documented in the form of reports, a presentation and a poster and was conducted in the months of December to March.
TYBSc Group Projects:
32 Students worked in groups of six students on Industrial Microbiology themes from July to September and wrote papers on their projects.
MSc II External project:
20 MSc Part II students worked on their external dissertations in premier institutes like ACTREC, BARC,TMH and NIRRH for 4 months from May to August 2018 while five internal projects were carried out by students in groups in the months of January to April.

18th Microbiolympiad :45 UG students of our department participated in the 18th Microbiolympiad, an all Maharashtra Microbiology quiz contest. During the preliminary round on the 9th January, 2019 our FYBSc students Sarah Thomas, Sayandrila Paul and Khushi Asnani together obtained the 1st rank, our SYBSc students, Maitri Khemka, Moumita Sengupta, Janhvi Jeswani, obtained the 7th rank and our TYBSc students , Shiva Joshi, Kartikeyan Premrajka, Leeza Elizabeth and Aradya Kapoor ranked 2nd amongst all Maharashtra colleges.

Research Paper Presentations:
- Rashmi Kokare participated as delegate and presented Oral Paper titled "Minimum Inhibitory Concentration(MIC) Results of Ceftriaxone and Azithromycin for Blood Culture Isolates of Nalidixic Acid Resistant Salmonella Enterica Causing Enteric Fever" in XXIV Maharashtra Chapter Conference of IAMM organized by Department of Microbiology, Krishna Institute of Medical sciences, Karad on 29th-30th September 2018.

- Joanna Pereira participated as delegate and presented Oral Paper titled "Comparison of Broth Microdilution Test Results of Colistin with VITEK 2 Compact for Carbapenam Resistant Gram-negative Bacteria (CRGNB)" in XXIV Maharashtra Chapter Conference of IAMM organized by Department of Microbiology, Krishna Institute of Medical sciences, Karad on 29th-30th September 2018.

- Rashmi Kokare presented Scientific Paper entitled 'In vitro activity of Tigecycline and comparators against Gram-positive and Gram-negative pathogens from multiple sites encountered in a tertiary care hospital in Mumbai' in the World Congress on Infectious Diseases & Antibiotics- 2018 held on 28th& 29th November 2018 held at Indian Institute of Science, Bengaluru, India.

- Joanna Pereira presented Scientific Paper entitled 'Minimum Inhibitory Concentration (MIC) of Ceftriaxone for Blood culture isolates of Nalidixic acid resistant Salmonella enteric- A 9 -year study' in the World Congress on Infectious Diseases & Antibiotics- 2018 held on 28th& 29th November 2018 held at Indian Institute of Science, Bengaluru, India.

 Student Awards at fests

BSc students:

*Sayandrila Paul (FYB.Sc) secured fourth position in the poster making competition organized by Marathi Vangmay Mandal (Lingua 2018) on 26th November, 2018 on the topic Commemoration of 26/11.

*Mathew Salazar and Maitri Khemka won the first prize at the Quiz Competition in the event PRIMERS held on 11th-12th December, 2018 whileKritika Choudhary participated in the Petrisign event and secured first position.

*Sayandrila Paul won second prize in Bio-Toon event at the Annual Intercollegiate Departmental festival- "Chimera 2018-19" held on 24th December 2018 and participated in Quick before Tick, Treasures of Biotechnica and Mutable Menicus.

*Kritika Choudhary and Ria Paul participated in Quick before Tick, Treasures of Biotechnica, Tetrad, Intellumis, Sherlock Genomes and Biotoon at the Annual Intercollegiate Departmental festival- "Chimera 2018-19" held on 24th December 2018.

*Kartikeyan Premrajka and Ishita Bapna attended 'BIOTECHNOVA' 18-19' conducted by Biotechnology Department, Mithibai College on 10th January, 2019.

*Rachel Faria participated in the one day seminar on 'Navigating the social media in a responsible manner' conducted on 26th February 2019 by Women Development Cell, St. Xavier's College (Autonomous), Mumbai.

*Marwan Malik, Maitri Khemka, Subhashri Acharya, Moumita Sengupta and Sanket Gosavi applied for PRE-iGEM competition 2019 under the guidance of Dr. Karuna Gokarn and Dr. Pampi Chakraborty.

 MSc Students

Mrunmayee Saraf was a member of the team which won the inter-collegiate quiz competition during Open Day organized at ICMR- National Institute for Research in Reproductive Health on 28th September, 2018.

MSc I students attended a talk on Laboratory safety "Disinfection: Challenges and the Way Ahead" on 23rd January, 2019 by Dr Imran Memon, Technical director , Imago and Getter.

Joanna Pereira participated in CME Programme on 'JPGMCON 2019- Journey from Research to Publication…' held on 23rd March 2019 at Seth G. S. Medical College & K.E.M. Hospital, Mumbai.

 Competitive exams:Several of our TYBScstudents cleared all India competitive exams for postgraduation which include the JEEBILS, JAM and Management. Nine of our MSc II students cleared the GATE exam and one was awarded the UGC-CSIR JR fellowship.

K. Faculty achievements

 Research Publications by faculty

Effect of Nanoparticles on Plant Growth-Promoting bacteria in Indian agricultural soil. Sangeeta Chavan, Vigneshwaran Nadanathangam, Agronomy, 2019, 9, 140

 Research grants

- Dr. Karuna Gokarn was the recipient of Mumbai University grant-teachers for a project on 'Repurposing of the over-the-counter drugs as antibacterial and anticancer agents'. The sanctioned amount is Rs. 35,000/-.
- Dr. Aparna Talekar was the recipient of Mumbai University grant-teachers for a project on 'Bacterial degradation of a wide spectrum of azo dyes from industrial effluents into non-toxic products'. The sanctioned amount is Rs. 25,000/-.

● Dr. Pampi Chakraborty was the recipient of Mumbai University grant-teachers for a project on 'Study of anticancer activity of wine prepared from banana.' The sanctioned amount is Rs. 25,000/-.

 Academic Achievement:

*Dr. Karuna Gokarn was conferred Doctor of Philosophy (Ph. D.) by University of Mumbai for thesis titled 'Extraction of siderophores from Mycobacterium smegmatis and their evaluation as novel therapeutic agents' under the guidance of Dr. Ramprasad B Pal from Sir HN Hospital & Research Centre, Mumbai at the Convocation held on 11th January, 2019.

*Dr. Pradnya Gogte was conferred Doctor of Philosophy (Ph. D.) by University of Mumbai for thesis titled 'Characterization and Optimization of *polybetahydroxybutyrate* production by microbial isolate obtained from soil' under the guidance of Dr. (Mrs.) Varsha K. Vaidya from The Institute of Science, Mumbai at the Convocation held on 11th January, 2019.

 Guiding student research projects and internships:

● Ms. Miriam Stewart guided M.Sc. part II project titled: "Method optimization for the isolation, extraction and characterization of the extra-polymeric substance (EPS) producers from mangrove environments of Palghar district

● Ms. Sangeetha Chavan guided M. Sc. part II Project titled: "Evaluation of plant growth promoting effects of rhizobacterial consortium isolated from Manori mangroves"

● Dr. Karuna Gokarn guided MSc.part II project titled "Bioremediation of polystyrene and polycyclic aromatic hydrocarbons: An effort to reduce environmental pollution"

● Dr. Aparna Talekar guided M. Sc. part II Project titled: "Isolation of Indole degraders, optimization of degradation parameters and probable biotransformation of Indole to Indigoids"

● Dr. Pampi Chakraborty guided MSc.Part II project titled"Evaluationof biopharmaceutical properties of pigments extracted from bacteria found in diversehabitats."

● Dr. Pradnya Gogte guided M. Sc. Part II Project titled- 'Isolation and Characterization of Heavy Metal Resistant Organisms for their potential use in Bioremediation'.

● Dr .Karuna Gokarn and Ms Sangeetha Chavan guided 36 SYBSc students who carried out 18 small Environmental projects in groups of 2.

● Ms. Miriam Stewart and Ms Sangeetha Chavan guided 32 students who carried out 6 TYBSc Industrial projects in groups of 5 or 6.

● Dr. Karuna Gokarn guided a four-month (July to October 2018) project titled "Extraction and Bioactivity based studies of Pomegranate Seed Oil" was completed by an M.Sc –II student in the PGDBT, St. Xavier's College.

● Dr. Karuna Gokarn guided a TYBSc Biotechnology student from Amity University, Noida for her one-month internship (1st March to 31st March 2019) on 'Cloning of siderophore genes'.

● Dr. Karuna Gokarn guided a SYBSc Microbiology student from Fergusson College, Pune for her one-month internship (2nd May to 31st May 2019) on 'Cloning of Exochelin MS genes'.

● Ms. Miriam Stewart taught Basic Microbiology techniques to Mr. Aniruddha Venkatakrishnan , a student of Broward College, Mumbai campus and in the First Year during a one month(16th March – 16th April 2019) internship in the Microbiology Department at St. Xavier's College, Autonomous, Mumbai.

 Seminars, Conferences and Workshops attended by Faculty outside college

● Dr. Pampi Chakraborty participated in a Workshop on 'Power of Microscope with high speed analysis of Flow Cytometry' held in ACTREC, Mumbai (24th July, 2018)

● Dr. Karuna Gokarn participated in A National Hands-on Training Workshop on Innovative Experiments in Biological Sciences for College Teachers' at Homi Bhabha Centre for Science Education, TIFR, Mumbai from 29th August – 4th September 2018.

● Ms. Miriam Stewart was deputed by the college to attend the 4th India International Science Festival, IISF -18 in Lucknow on the 5th-8th Oct, 2018 under the DBT-STAR Program.

● Dr. Karuna Gokarn participated in a three-day workshop on Synthetic Biology at ICT, Mumbai from December 13-15, 2018.

● Dr. Karuna Gokarn attended a conference on "Precision Medicine is closer than you think and also chaired a session on Translational research in cancer at ACTREC, Navi Mumbai.

● Dr. Karuna Gokarn and Dr. Pampi Chakraborty attended a Two-Day Workshop on "Research Methodology & Research Data Analysis" conducted by the Department of Biotechnology, University of Mumbai. (25th -26th February 2019)

● Dr. Karuna Gokarn attended a seminar on "SSS as a Quality Practice" conducted by the IQAC at Vaze College, Mumbai in March 2019

● Ms. Miriam Stewart attended the International Science Conference: from Health to Well Being: An Interdisciplinary approach from Fundamental Sciences to Translational Medicine, at St. Xavier's College Mumbai from the 9th – 11th Jan, 2019.

● Dr. Aparna Talekar participated in a short-term course on, Biostatistics: a user's perspective' at IISER, Pune from 27th December 2018 to 30th December 2018.

● Dr. Aparna Talekar participated in the LTMT sponsored teacher training programme on 'Experimental Approach for Drug Studies' from 17th – 19th January, 2019 at Sophia College.

● In-house

Ms. Miriam Stewart, Ms. Sangeetha Chavan, Dr. Aparna Talekar and Dr. Pradnya Gogte attended the National Seminar on 'Fostering Entrepreneurship- Startup as a Stepping Stone' held by St. Xavier's College (Autonomous), Mumbai under the patronage of Rashtriya Uchchatar Shiksha Abhiyan (RUSA) on 3rd February 2019 on the occasion of the digital launch of "Entrepreneurship Cell and Skills Hub" by Hon'ble Prime Minister Shri Narendra Modi.

Other faculty activities

- **Orientation/refresher programme**

● Dr. Aparna Talekar and Dr. Pampi Chakrabortyparticipated in a three-week refresher course in Environmental Studies at Somaiya college, Vidyavihar from 1st June to 21st June 2018

- **Subject Expert**

● Ms. Miriam Stewart was Microbiology Subject Expert to interview candidates for a full-time faculty appointment for the Academic year 2019-2020 at Jai Hind College, Mumbai on May 3rd, 2019
● Ms. Miriam Stewart was appointed as Subject expert to the Microbiology Board of Studies of K.J Somaiya College of Science and Commerce.
● Ms. Miriam Stewart was appointed as Subject expert to the Microbiology Board of Studies of Sophia College(Autonomous)
● Ms. Miriam Stewart continued as Chairperson on the Microbiology Board of Studies of St. Xavier's College(Autonomous) and Ms Sangeetha Chavan, Drs K Gokarn, A. Talekar and P Chakraborty are Members.

● **College committees**

● Miriam Stewart was Convener of Infrastructure Committee and Member of Custodians committee of Exam Papers
● Sangeetha Chavan was Member of The Women's Development Cell and TAQ committee
● Dr.KarunaGokarn was Member of the Library Committee , Member of the Research Committee and was appointed as DBT-STAR Co-ordinator of College, IQAC
● Dr. Aparna Talekar was Member of the Institution Biosafety Committee (IBSC Laboratory safety committee, Magazine committee, Internal Biosafety Committee (IBSC), RUSA purchase committee)
● Dr. Pampi Chakraborty was Member of the Research Committee in College,Department Honour's Programme Co-ordinator for the Department.

- **Honour's Programme**

*Ms.Miriam Stewart conducted a workshop to study the Antimicrobial Activity of Indian Herbs and Spices.

*Dr. Pampi Chakrabortyconducted a workshop on Animal tissue culture

*Ms.Sangeetha Chavan conducted a series of lectures cum demonstrations on 'Microbiology in everyday life' for students from non-biology background .

*Dr. Aparna Talekar conducted a series of lectures cum demonstrations on 'Microbiology in everyday life' for students from non-biology background.

Ms.Miriam Stewart Conducted sessions on the "Biodeterioration and Conservation of Paintings and Manuscripts using lectures and practical demonstrations at the UGC sponsored Diploma Course on Conservation and Preservation of Material Culture in St. Xavier's College on 18th June to 5th July,2018.

Ms.Sangeetha Chavan was part (resource person) of a one-day workshop conducted for Science teachers of grades 7 on 2nd November 2018 in Caius Research Laboratory
As a member of WDC was part of the organizing team for the one-day seminar 'Navigating the social media in a responsible manner' on 26th Feb 2019.

The Department has had a very successful Academic year 2018-2019 with a plethora of activities which encouraged learning and brought home a number of accolades. We firmly believe that developing academic and social responsibilities in our students and igniting our own potential benefits society and our Nation.

Ms. Miriam Stewart
Head of Department

MSc External Projects

Name : Tejasvita Awale (188601)
Institute : Bhabha Atomic Research Centre
Guide : Dr. Ajay Saini
Project title : Purification, characterization and in vivo functional analysis of rice manganese superoxide dismutase.
Abstract : All the abiotic components in the environment play important roles in all life forms. Variation in the optimum levels of abiotic components often results into stress to the organism. Plants being sessile are more prone to environmental perturbations and stress conditions, and have evolved diverse array of mechanisms to contain and overcome the stress induced cellular damage. If not contained, environmental stress mediated cellular damage results into substantial reduction in productivity of almost all crops. Reactive Oxygen Species (ROS) are physiologically important however their elevated levels results into 'Oxidative Stress' to the cell. Oxidative stress causes extensive damage to cellular components and therefore the ROS needs to be scavenged. To achieve this, plants harbor several antioxidant mechanisms including enzymatic as well as non-enzymatic. One of the most important antioxidant enzymes is superoxide dismutase (SOD), various isoforms of which are localized to cytosol and organelles (chloroplast, mitochondria and peroxisomes) involved in oxidative metabolism. MnSOD is a SOD type that is localized in mitochondria and contains Mn at the catalytic center of the enzyme. In the present study, the rice MnSOD lacking N-terminal signal peptide (referred to as ΔSP-MnSOD) was cloned and, overexpressed in the E. coli. The recombinant protein was purified and its biochemical biophysical properties were characterized. The ΔSP-MnSOD activity was analyzed by a standard SOD assay that involves spectrophotometric measurement of NBT reduction at 540nm. Effect of parameters such as temperature, pH, and additives like EDTA, Urea, DTT, and SOD inhibitors like sodium azide, H2O2 on the rice protein was analyzed. Differential Scanning Fluorimetry (DSF) was carried out to study the thermal stability of the recombinant protein. Further, the antioxidant function of the rice MnSOD was analyzed, in vivo in E. coli sod single and double mutant cells exposed to methyl viologen that induces oxidative stress. Rice MnSOD conferred protection to E. coli cells against MV induced oxidative stress. Future work will be focused on the comparative biochemical and biophysical analysis of the MnSOD variant proteins.

Name : Wayne Barreto (188602)
Institute : P.D.Hinduja hospital and medical research centre
Guide : Dr. Camilla Rodrigues
Project title : Comparison of phenotypic tests (culture) against molecular tests of tuberculosis bacteria by genexpert thereby to obtain an incremental value
Abstract :Tuberculosis (TB) in general is a contagious, and infectious disease, due to Mycobacterium tuberculosis Bacteria (MTB) hence it has always been a challenge over the course of human history, because of its severe social implications. In 1720, for the first time, the infectious origin of TB was conjectured by the English physician Benjamin Marten, while the first successful remedy against TB was the introduction of the sanatorium cure. The famous scientist Robert Koch was able to isolate the tubercle bacillus and presented this extraordinary result to the society of Physiology in Berlin on

24 March 1882. The following study to be carried out between molecular tests against phenotypic tests and to determine which is the most efficient from the above two mentioned. These tests are done to study about mycobacterium tuberculosis. To study the tests two techniques were deployed one being molecular diagnostic method in the form of GeneXpert and the other test being culture. The Xpert uses the Cepheid system, Xpert cartridges and Lysis solution to carry out the following test. In the culture method the NALC-NAOH mixture is used along with MGIT (Mycobacteria growth indicator) Tubes supplemented with growth media in the form of middles brook 7H11 media and LJ medium glass bottles respectively. The key step of NALC-NAOH decontamination is carried out and when the sample is tested positive it's then subjected to MPT-64 test, which is a rapid test to detect tuberculosis. GeneXpert being one of the assay that has been approved by WHO to detect tuberculosis both in pulmonary as well as Extra pulmonary TB. The sensitivity and specificity of Xpert is 98% & 93% in comparison to culture. However though Culture is the Gold standard but due to longer turnaround time (TAT) requires assays which are rapid, sensitive and less laborious. Thus after carrying out a successful study the highest efficiency was obtained in molecular diagnosis and that was even proved by an incremental value of 27% in the favor of molecular diagnostic tests. Thus one thing established from this study is that molecular diagnostic method is the future for TB detection and its one of the most sensitive and reliable tests in the market at present.

Name : Jewelrose Johnson (188603)
Institute : Amala Cancer Research Centre
Guide : Dr.K.K. Janardhanan
Project title : Aqueous ethanolic extract of *Morchella esculenta* mycelia attenuates cyclophosphamide induced cardiotoxicity in mice
Abstract : "Treatment of cancer is notoriousnot only for its chance of failure but also for the side effects of the drugsused for treatment. Cyclophosphamide is a commonly used and efficient anti-neoplastic drug which belongs to the family of alkylating agents. The adverse side effects of this drug are then deleterious effects on the myocardial tissue leading to cardiac arrest. *Morchella esculenta* is an edible mushroom known to have significant therapeutic properties. The mycelium of this mushroom is also known to possess the similar beneficial properties. The main objective of the current studies was to evaluate the cardioprotective effect of the aqueous ethanol extract of the *M. esulenta* mycelia against cyclophosphamide induced cardiotoxicity. The study was carried on animal models and was administered with cyclophosphamide to induce cardiotoxicity. Cardioprotection was evaluated by determining the levels of cardiac marker enzymes, creatine kinase- muscle brain (CK-MB), lactate dehydrogenase (LDH) in the serum and antioxidant status of the myocardial tissue. Animals pre- treated with the aqueous ethanol mycelial extract were capable of reducing the tissue damage caused by the cyclophosphamide administration as evident from the low levels of CK-MB and LDH in serum in a dose dependent manner. The antioxidant status of myocardium was determined by MDA, GSH, SOD and GPx assays. The depletion of antioxidant activity due to cyclophophamide treatment was restored on the treatment with mycelial extract. These results indicated that the aqueous ethanolic extract of *Morchella esculenta* mycelium possessed significant cardioprotective effect. The findings thus suggest that the morel mushroom mycelia can be a potential therapeutic agent for preventing cardiac injury .

Name : Shivani S Dharmadhikari (188604)
Institute : Bhabha Atomic Research Centre
Guide : Dr. S. T. Mehetre
Project title : Enhancing the iron uptake in finger millet with the help of siderophore producing bacteria.
Abstract :"Iron is an essential micronutrient for plant growth and development. Besides, it is also an extremely important aspect of human health. In the recent past there has been a constant rise in cases of anemia worldwide and the most common cause of anemia is iron deficiency. Efforts are being made for artificial supplement of iron or through diet for increasing the iron intake of individuals. But the artificially supplemented iron may not be bioavailable for the body. So there is an urgent need for iron supplements through plant origin. Iron bio fortification is a radical approach to enrich plants and their food products with iron in order to alleviate cases of iron deficiency caused due to low iron consumption in the diet. In view of this, attempts were made for isolation and screening of siderophore producing bacteria and thereby formulate a potential bio fertilizer in order to enhance the iron uptake by Finger millet (*Eleusine coracana*) plants (Variety ML-365). Soil samples from rhizosphere of Winged bean (*Psophocarpus tetragonolobus*) (being a high iron containing plant) and Turmeric (*Curcuma longa*) and cow dung were used for isolation purpose. Bacterial isolates growing on universal Chrome Azurol Sulphonate (CAS) Agar medium were taken for further study. The selected siderophore producing bacterial strains were applied along with nutrient medium used for finger millet plants at various stages of growth. Bacterial isolates were applied individually as well as in consortium. All the strains showed positive growth promoting ability and also promoted the enhancement of root growth as compared to control.To confirm the iron uptake by plants the leaves samples were taken, acid digested and analyzed by Atomic absorption spectroscopy. The results showed enhanced uptake of iron in the plants inoculated with siderophore producing bacteria.The present study not only broadens our understanding of different types of siderophore producing bacteria and their potential in plant growth and nutrition but also highlights its potential role in application as a bio fertilizer for iron fortification and growth promotion in the Finger millet plants."

Name : Nimesha N. Fernandes (188605)
Institute : National Centre for Polar and Ocean Research
Guide : Dr. K.P. Krishnan
Project title : Characterisation of cold tolerant bacteria from Arctic
Abstract : Glaciers and ice sheets are the Earth's unique biome. Glaciers are important as they indicate the climatic change and the increase in global temperature. Microorganisms in glaciers explains about the nutrient dynamics as they are responsible for soil development, biogeochemical cycle and heterotrophic activities. It was studied that bacterial cell concentration in glacial habitat varied depending upon the nature of the habitat, the depth of the sample, temperature extent, availability of nutrients and climatic change. Microbes in glaciers can contribute to bioheat as a consequence of their metabolic activity which can also contribute to glacier retreat. Hence, studying these microorganisms is very important. Along with taxonomic identification it is very important to learn their enzyme producing potential and carbon utilizing capabilities. We hypothesize that different bacterial isolates will exhibit different biochemical and enzyme producing potential along with different metabolic profiles in carbon utilization. We retrieved 13 isolates from the Arctic glaciers to work on our hypothesis. Growth curve test was performed to determine the optimum temperature and salt concentration required by each isolates along with their ability to produce different enzymes and carbon utilizing potential. Antibiotic susceptibility test was also performed. Results

showed that majority of the isolates were psychrophiles and they showed flexibility to adapt to wide range of salt concentration. Diverse results were observed for enzyme production and carbon utilization assay and they were found to be resistant to most of the antibiotics. These studies carried out on each of the bacterial isolate showed that each of them are different from the other isolate. Hence, more detailed study of these bacterial isolates will explain us their ecological role in more detailed manner.

Name : Princita Fernandes (188606)
Institute : National Centre for Polar and Ocean Research
Guide : Dr. K.P. Krishnan
Project title : Assessment of heavy metal tolerance in Arctic bacteria
Abstract : Studies on the assessment of heavy metals on the bacterial isolates of the Arctic indicate their potentiality to grow in the presence of these heavy metals which may be a useful tool for the bioremediation of heavy metals predominating in the Arctic environments.For our study, bacteria were isolated from fjord and glacier melt water associated stations in Kongsfjorden, West Spitsbergen in the Arctic region. The tolerance of these isolates were determined by Minimum inhibitory concentrations (MIC) using different concentrations of the heavy metals (Hg, Cd, Zn, Pb, Co, Ni and Mn)
The cell count of each bacterial isolate was estimated by DAPI stain using epiflurorescence microscope. Furthermore, Antibiotic Sensitivity Test (AST) was performed. Mercury (Hg) was found to be the most toxic metal since the isolates treated with Hg were able to tolerate the least concentration i.e. 5µM, followed by lead (Pb), Cobalt (Co) and cadmium (Cd). Most of the bacterial isolates exhibited resistance to a wide range of antibiotics. Form this study, it can be thus concluded that there is a positive correlation between heavy metal tolerance and antibiotic resistance.
Key words: Arctic, heavy metal, MIC, antibiotic .

Name : Sumedha Garyali (188607)
Institute : National Institute for Research in Reproductive Health (NIRRH)
Guide : Dr. Pallavi Shukla
Project title : Mitochondrial dysfunction and associated risk factors in infertile women
Abstract : Female infertility is a growing problem in the modern time, causes of which range from an underlying medical condition to lifestyle choices. The present study was undertaken to investigate mitochondrial dysfunction in infertile women. Mitochondrial activity and their number are essential for the process of fertilization and maintaining the quality of embryo. Its dysfunction can arise from complications in ETC and ATP-synthesis machinery, insufficient number of mitochondria, or due to the inability to provide required substrate to mitochondria. Since mtDNA copy number can act as an indirect measurement of mitochondrial dysfunction, it was evaluated, along with activity of enzyme superoxide dismutase (SOD) that is involved in the body's antioxidant defense system, and correlation of mtDNA copy number with various metabolic risk factors and anthropometric indices. 30 infertile and 15 healthy control women were recruited for this study. DNA was extracted from peripheral blood samples and was used for estimating the copy number by real time PCR. Serum samples were used for checking the activity of SOD by immunoassay and for analyzing the clinical, hormonal and biochemical profile of these participants. Copy number of mtDNA was found to be significantly lower in infertile women (mean=1.30) and more in healthy control women (mean=1.63). SOD activity was significantly higher in infertile participants (mean=0.80) as compared to healthy control women (mean=0.73). Both the results were statistically significant. Negative correlation was seen between mtDNA copy number and insulin resistance

(HOMA-IR) (p=0.031*) and mtDNA copy number and waist to hip circumference ratio (p=0.033*) after adjusting for confounding factors like BMI and age. P value of <0.05 was considered as statistically significant and SPSS statistical software was used for this correlation analysis. Clinical, hormonal and biochemical profile of infertile participants showed an increase in their BMI, AMH, HOMA-IR, LDL cholesterol and HS-CRP values. All these results indicate increased oxidative stress, damaged mitochondrial activity and unhealthy lifestyle choices in infertile women.

Name : Abigayle De Graca Gomes (188608)
Institute : National Institute Of Oceanography
Guide : Dr. Ray Durbar
Project title : Microbial Quality and Antibiotic Resistance in Mandovi- Zuari Estuarine Complex
Abstract : The Mandovi-Zuari estuarine environment of Goa on the west coast plays an important role in the socio-economic development of the coastal state. Due to anthropogenic activities near the estuarine region as well as river transport, local fisheries, and recreational activities this estuarine water receives various wastes from different sources. In that connection to assess the environmental quality, the water and sediment from this estuary is regularly monitored under National Sea Water Quality Monitoring program. Recently for this multidisciplinary monitoring program, several water and sediment samples from Mandovi-Zuari estuarine water were investigated for physico-chemical and microbiological parameters. Here we are presenting the microbial quality of this estuarine water; particularly the microbial counts and the distribution of selective pathogens during pre-monsoon in April 2019. The results show the absence of immediate pollution indicators such as coliforms, however; a few pathogenic species of bacteria such as Vibrios *(V.cholerae, V.parahaemolyticus, V.vulnificus), Pseudomonas (P.aeruginosa), Shigella and Enterococci (E.faecalis)* were detected in the estuarine water and sediment. A selected set of 40 bacterial isolates belonging to those aquatic pathogens were tested against 16 different antibiotics to assess their resistance towards commonly used drugs. This antibiotic resistance study showed that most of the isolates had resistance against commercially used antibiotic like Clindamycin. Two of the isolates showed resistance up to 9 tested antibiotics. Such pathogenic strains with resistance to multiple antibiotics might pose serious threat to the water quality in this estuarine habitat. Studies on the seasonal variation in the occurrence of these pathogenic strains and their increase in antibiotic resistance among the pathogenic organisms can provide vital information for effective environmental management.

Name : Shraddha Gore (188609)
Institute : Radiation Medicine Centre, BARC
Guide : Dr. Pramod Kumar Gupta
Project title : Investigation of RSV mediated host immune modulation in MTB infected RAW cells
Abstract : Tuberculosis is amongst the top reasons for mortality caused due to infectious diseases. The evolution of bacteria, growing incidence rate of MDR & XDR TB have made the treatment of the disease challenging which necessitates the development of a novel drug. Host directed therapeutics using plant extracts is an emerging concept in treatment of tuberculosis. These drugs modulate the host immune response, reducing the development of resistance in bacteria. Resveratrol is one such HDT agent which helps in induction of autophagy making it an essential tool for drug formulation against TB. In the present study the anti-Tuberculosis property of Resveratrol were investigated. MTT assay confirmed that RSV below 100µM concentration is not cytotoxic to murine macrophage

cells. Intracellular survival of MTB under the effect of the drug at a range of 10µM-50µM was observed using CFU assay. Treatment with RSV inhibited the intracellular survival of MTB in murine macrophage line in a dose dependent manner. The administration of RSV with INH enhanced the efficacy of INH and exhibited an increase in clearance of intracellular MTB compared to individual effect of INH & RSV. The MIC of RSV for MTB was found to be 100µM using REMA assay. Collectively the data showcases that RSV shows anti-Tuberculosis activity by clearance of intracellular MTB, enhanced efficacy of INH and increased glycolytic capacity in MTB infected cells. Further research should be done to investigate mechanism of action of RSV, its efficacy, effectiveness at various parameters and its potential as a therapeutic drug.
Key: Resveratrol, host directed therapy, MTB

Name : Pratiksha kalambe (188610)
Institute : National Institute of Research in Reproductive health
Guide : Dr. Dhanjit Kumar Das
Project title : Identification of Genetic Variants in SRD5A2 gene in Patients with Disorders of sex development
Abstract : When a new-born with ambiguous external genitalia is born, the immediate question arises in front of the doctor as well as a parent is of sex assignment. Even before the initial shock is over the parents are further subjected to more stressful medical and life long social stigma associated with such conditions. This situation is medically termed as the disorders of sex development which include any problem with atypical genitalia in relation to chromosomes and gonads. There are many causes for the DSD, either due to the abnormality in biochemical pathways or gene mutations that are responsible for the formation of genitalia. Early diagnosis of DSD is very important so that patient can receive a proper counselling and hormonal therapy. The persons with SRD5A2 gene mutations are genetically male with normal XY chromosomes; however, they are born with ambiguous genitalia. The genitalia may be premature (micropenis or hypospadias) or mostly like female genitalia. The objective of this study is to screen the people with SRD5A2 mutation and determine the pathogenicity of mutations in causation of DSDs that ultimately results in hormonal imbalance.SRD5A2 gene translates the Steroid 5-α reductase enzyme that converts testosterone to dihydrotestosterone which directs the development of external as well as internal genitalia in a male. Any mutation in this gene changes the function of steroid 5-α reductase 2 protein, which leads to loss of function or decrease in enzyme activity. In this study the Exon 1-5 region of SRD5A2 gene was analysed successfully for mutations in 14 DSD patients. One patient showed a pathogenic mutation of G737A in Exon 5 and 6 patients showed V89L polymorphism. However, it is important to perform large cohorts' analysis of 46, XY DSD patients to demarcate novel candidate genes and to study genotype-phenotype correlations necessary for the genetic diagnosis of these syndromes.

Name : Ankita V. Lakhotia (188611)
Institute : Bhabha Atomic Research Centre
Guide : Mr. Dhiman Chakravarty
Project title : Role of conserved amino acids in the active site region of KatB , a Mn-containing catalase from nitrogen fixing cyanobacterium *Anabaena* PCC 7120.
Abstract : Catalase, a ubiquitous enzyme carries out the reaction of decomposing hydrogen peroxide into water and molecular oxygen, and is virtually present in all aerobic organisms. *Anabaena PCC 7120* is a filamentous, non branching, freshwater *cyanobacteria* capable of fixing atmospheric nitrogen byspecialized cells known as the heterocyst. The genome of *Anabaena PCC7120* shows the presence of two genes (katA and

katB) coding for Mn-catalase. Of these two genes, katB plays a vital role in adaptation to salinity and oxidativestress in *Anabaena PCC 7120*. Multiple sequence analysis shows the presence of few conserved amino acid residues and crystal structure of KatB indicated that these residues are present in the active region holding the two Mn atoms at the catalytic centre. There are few second shell interacting residues which do not interact with the Mn atoms directly but influences the positioning of the active site residues in the 3D space. The present study is aimed to validate the role played by two of these important amino acid residues; Glutamate-163 and Tyrosine-140. Site directed mutagenesis was carried out to generate KatB variants substituting those amino acids with alanine individually and in combinantion. The resultant variants were named as: katBE163A (where Glu-163 was substituted with Ala), katBY140F (where Tyr-140 was substituted with Phe) and katBY140F/E163A (where both Tyr-140 and Glu-163 were substituted with Phe and Ala respectively). All these mutated versions were cloned into pET21a vector and transformed into E. coli expression host. Following the IPTG induction, purification of the over-produced proteins from the soluble fraction was attempted. The KatBE163A and KatBY140F/E163A formed inclusion bodies indicating that Glu-163 is structurally important. Attempts were made to purify these two variants from inclusion bodies using various methods by employing n-alkyl alcohol and urea solubilization. E163A mutation led to unusual strong binding of C-terminal hexa histidine tagged protein variants. However, the KatBY140F variant could be purified from the soluble fraction and the it showed 60% reduction in the activity compared to the wild-type KatB protein. With respect to the wild-type KatB protein, KatBY140F showed comparable secondary structure and thermal stability as detemined through CD spectropolarimetry. Overall, the current study shed light on the involvement of the conserved second shell interacting residues in maintenance of the structure-function relationship.

Name : Stefan H. Manki (188612)
Institute : National Facility for Biopharmaceuticals
Guide : Ms. Valencia D'souza
Project title : Evaluation and purification of antimicrobial peptides/bacteriocin produced by bacteria isolated from different sources like raw milk, curd and soil
Abstract : Bacteriocins have antimicrobial activities against food-spoiling bacteria and food-borne pathogens. Bacteriocins are low molecular weight antimicrobial peptides produced by bacteria (particularly lactic acid bacteria) that are inhibitory to other bacteria, which are usually closely related to the producer bacteria. Bacteriocins are ribosomally synthesized low-molecular weight peptides or proteins with potential use in food preservation due to their bactericidal effects on food spoilage and pathogenic organisms.In the present study soil sample was taken from the local garden in Mahim and screened for potential AMP producers . A total of 10 isolates were found and only 4 were chosen due to the inhibitory activity performed for the isolation of AMP producers. AMP producer were grown in MRS medium where they produced AMPs extracellularly. Which was extracted by solvent extraction of the cell free supernatant . After solvent extraction the crude extract obtained was checked for the presence of AMPs by Tricine SDS-PAGE followed by Antimicrobial activity.The spectrum analysis of the crude extract was done so that to prove the presence of AMPs.The Antimicrobial activity was checked against 2 cultures that were *S.aureus* and *E.coli* . the four isolates showed more inhibitory action against Gram positive culture ie. *S.aureus* proving that there is presence of AMPs and confirmed by the spectrum analysis via the UV-vis spectrophotometer which showed a peak around 215-225nm as it the ideal range for peptide maximum absorbance.As the extract was the thus further purification needs to be done to obtain pure form of AMPS which can later be useful in various applications.

Name : Juili. E. Mirgule (188613)
Institute : Indian Institute of Technology Bombay
Guide : Dr. Prakriti Tayalia
Project title : Impact of porogens on spheroid formation in scaffold based systems for development of in vitro 3D tumor models
Abstract : In vitro 3-dimensional spheroid tumor models have a great potential for their use in cancer research and for the development of anticancer therapies. However, for spheroids to be used as tumor models, their size should fall in the range of 200-500µm and they must harbor cells in different stages of growth, thus, forming distinct zones in the spheroids so that they accurately replicate the in vivo tumors. In this study, scaffold porosity was enhanced using the porogen leaching method. Scaffolds were synthesized using a blend of the polymers polyethylene glycol diacrylate and gelatin methacrylate. The polymers were crosslinked using the free radical mechanism in the presence of a porogen (NaCl) with an aim to increase the porosity and mean pore-size of the scaffolds. Effect of porogen leaching was determined on the physical properties of the scaffolds using liquid displacement, SEM imaging, swelling ratio, compression and degradation analysis. Also, the effect of porosity on the growth and development characteristics of the B16F10 spheroids in the scaffolds was evaluated. It was found that the porogen strongly influenced the physical characteristics of the scaffolds and gave rise to higher level of porosity,swelling behavior and degradation characteristics in the porogen treated scaffolds compared to the control. However, a significant difference could not be established in the spheroid sizes for the test and control scaffolds in a duration of 7 days thus, indicating that the spheroid culture time along with the scaffold porosity is a determining factor in the development of large sized spheroids.
Key words: 3-D, scaffold, spheroid, porogen, porosity, PEGDA, GELMA.

Name : Jissmole Pallithanam (188614)
Institute : Bhabha Atomic Research Centre
Guide : Dr. Shashidharan R
Project title : Characterization of hypothetical proteins STM2008 and STM3343 of *Salmonella Typhimurium LT2*
Abstract : *Salmonella enterica* serovar *Typhimurium* (STM) is an important food borne pathogen and impacts on human health. Many proteins from its genome are hypothetical proteins. These functionally unknown proteins indicate an important biological role in bacterium. STM2008 and STM3343 were selected using certain criteria which is found to be conserved. General prediction of biochemical function are provided by computational analysis but not their specific biological functions which have to be established through direct experimentation. Therefore, efforts are put to know the function of hypothetical proteins. The approach used here to determine the function of hypothetical protein is through knock out mutation, overexpression and its RNA expression in different conditions. The inability to knockout STM2008 indicates it to be an essential gene. STM3343 knockout was successful and hence its not an essential gene and STM3343 also showed an increase in mRNA expression in starvation and heat shock condition. This approach used was important to assign function to the hypothetical proteins STM2008 and STM3343 and also aims to understand the mechanism by which the bacterium adapts to different extreme environment and also to find targets having biotechnological interest.

Name : R Prabha (188615)
Institute : Indian Institute of Technology Bombay
Guide : Dr. Prakriti Tayalia
Project title : Biomaterial based injectable scaffold for immunotherapeutic applications
Abstract : Injectable based biomaterials are explored increasingly to reduce complications and risks related with surgical implantation. Implantable biomaterials are known to release or recruit cells locally for applications including drug delivery, vaccines, tissue engineering and gene therapy. However, limitations like patient compliance, risk of infection, inflammation at the surgical site leads to reduced performance of the implanted scaffolds. Injectable scaffolds can be used to overcome the limitation thereby providing minimal invasiveness and higher therapeutic efficacy. In this study, a cryogel based injectable system has been developed and characterized for its implications in immunotherapy. Gelatin methacrylate (GelMA) was used as a major component of the cryogel along with Poly ethylene glycol (PEG) to develop a system that is injectable, porous and biocompatible. GelMA was synthesized from gelatin type II and its formation was characterized using NMR and FTIR analysis. GelMA or in combination with PEG was then used to prepare cryogels by free radical polymerization and cryotropic gelation. The developed cryogels were further examined for their pore size distribution and mechanical strength using SEM and UTM respectively. Further, these cryogels were subjected to injectability, biocompatibility and enzymatic biodegradation studies. Results show that they GelMA-PEG based cryogels showed a highly porous nature in compared to GelMA. Mechanical analysis did not show any significant difference between these cryogels but showed an elongation modulus of MPa and a signification percent elongation. Biocompatibility tests show that approximately 70% of the cell were viable when cultured along with the developed cryogels. Injectability tests showed that GelMA-PEG cryogels maintained their structure and integrity when plunged through the 16G needle whereas GelMA cryogels did not pass the injectability test. Enzymatic degradation studies showed that the GelMA based cryogels were slowly degraded than gelatin based cryogels. The developed system proved to be a stable, injectable and biodegradable matrix that can be used as a for various immunotherapeutic applications.

Name : Anushka Raghubansi (188616)
Institute : Radiation Medicine Centre, BARC
Guide : Dr. Archana Damle
Project title : Effect of epigenetic modulator *5-Aza deoxycytidine* on different thyroid carcinoma cell lines.
Abstract : Cancer is the uncontrolled proliferation of cells in the body leading to tissue deterioration. Thyroid is the largest endocrine gland of the human body. Thyroid cancer occurs in less than 1% of population around the world with females being the most affected ones. In this study epidrug *5-Aza cytidine* was used to study its action against different thyroid carcinoma cell lines viz., ARO and NPA. *5-Aza* acts on DNA and causes hypomethylation and thus can be used to repurpose silenced genes in cancer. The study includes checking for cell viability by MTT Assay and Calcein AM Assay, cell survival by Clonogenic Assay, cell migration by Wound healing Assay, Cell cycle analysis by Pi staining and Western blot to analyse various proteins. Concentrations of *5-Aza* used were 10, 7.5, 5, 2.5 μM. results from MTT Assay were not conclusive hence Calcein AM was used to determine the IC50 and it was found to be 4.36 μM in NPA. In migration assay clear ridge was seen in all concentrations as compared to control after 24 hours. Clonogenic assay showed decrease in number of clones with increase in drug concentration. Substantial increase in sub G1 cell population was seen in cell cycle analysis using Pi staining. On western blotting P-38, PARP, P-44,42, Bcl-XL and Cas3 and

Cas7 were visualized. Our preliminary understanding from this project states that *5-Aza* is an active cytotoxic agent against Thyroid cancer cell lines and induces apoptosis in cells.
Key words: Aza, Thyroid Cancer, NPA, ARO, Epidrug.

Name : Riya Maria (188617)
Institute : Bhabha Atomic Research Centre
Guide : Dr. Sahayog N. Jamdar
Project title : Efficacy of dietary fiber utilisation by *Bacteroides sp*
Abstract : One of the most abundant bacteria in the gut microbiota are *Bacteroides*. These bacteria can utilize complex polysaccharides as energy sources. *Bacteroides* are usually mutualistic but they may also act as opportunistic pathogens. *Bacteroides fragilis* is the most clinically important species. The growth characteristics of *Bacteroides fragils* and *Bacteroides ovatus* in the presence of inulin, psyllium husk, and Locust bean gum was studied. The fibers used were also irradiated to study if this enhanced utilization by the organisms. This was compared to its growth in the presence of glucose and the absence of a carbohydrate. Inulin and irradiated inulin both showed growth higher than glucose for both *B. fragilis* and *B. ovatus*. Irradiated psyllium husk showed higher growth as compared to unirradiated psyllium husk. Both irradiated and unirradiated locust bean gum showed similar growth. Gram negative bacteria like *Bacteroides* are known to release spherical outer membrane vesicles (OMV) from the outer membrane. OMVs have been shown to selectively package certain proteins and enzymes depending on the environment. In the presence of complex carbohydrates hydrolytic enzymes may be present in OMVs. To study this the protein profiles of the cell pellet and OMV from B. fragilis were studied using SDS-PAGE. The presence of proteases and glycosidases were studied with in vitro assays. The differences in the protein profiles could not be quantified and further analysis is required.

Name : Mrunmayee Saraff (188618)
Institute : Radiation Medicine Centre, BARC
Guide : Dr. Avik Chakraborty
Project title : Evaluation of anti-proliferative effect of bedaquiline on anaplastic thyroid cancer and its synergism with shikonin
Abstract : Anaplastic thyroid cancer (ATC) is an undifferentiated type of cancer that has high metastatic rate and poor prognosis. Survival chances of patients suffering from ATC are around 25% and median survival rate is around 6-12 months. Resistance of tumour cells to existing chemotherapies and treatment failure makes development of new chemotherapeutic agents, a necessity. Discovery of new drugs is extremely time-consuming and hence repurposing of already existing, licensed drug becomes a smart choice.We have repurposed bedaquiline, an anti-TB drug for the treatment of ATC. Also, we have evaluated its combinatorial effect with shikonin, a tumour specific PKM2 inhibitor. The anti-proliferative effect of bedaquiline was deciphered using MTT assay, Clonogenic assay and PI staining method. Metabolic profile of cells which were given the drug treatment was analysed using metabolic flux analyzer.Bedaquiline was shown to inhibit ATP production as well as glycolysis. Synergistic effect was observed when combination treatment of bedaquiline and shikonin was assessed. Bedaquiline can thus be an attractive candidate for therapeutic purpose. Keywords: drug repurposing, anaplastic thyroid cancer, bedaquiline, shikonin.

Name : Saniya A. Satam (188619)
Institute : Radiation Medicine Centre, BARC
Guide : Mr. Kumarasamy Jothivel
Project title : Transformation,Overexpression and Purification of Recombinant Anti-thyroglobulin Single domain antibody KT77 in *Escherichia coli BL21*(DE3) Cells
Abstract : Conventional polyclonal antibodies have been in use as diagnostic tool since many years. However, targeting specific hidden epitopes of a particular antigen requires antibody to be able to penetrate effectively without losing its specificity. Conventional antibodies cannot bind deeper epitopes because of their bulky structures. In order to raise a good quality antibody with high penetrability and equally high specificity for thyroglobulin, it is important to have a smaller antibody called single domain antibody, which we have produced by carrying out its overexpression and purification.
This study focused at producing anti-thyroglobulin nanobody, KT737377. This nanobody is expected to bind thyroglobulin and hence can become a great tool in diagnostics and therapeutics in future, especially against thyroid cancer. In this study, *Escherichia coli Rosetta Gami B* (DE3) cells were transformed with pET32a (+) plasmid having desired antibody gene. The transformed colonies were screened by performing colony-PCR, AGE, brief induction and overexpression, after which single colony was selected. Overexpression of protein was carried out using 1mM IPTG and Ni-NTA purification was performed. Purity of Ni-NTA fractions was checked by performing SDS-PAGE and silver staining.Transformation was found to be efficient due to Ampicillin resistance conferred to cells by the plasmid insert. Screening tests helped in selection of single colony with high target protein overexpression. Induction, overexpression and purification of this screened colony, provided maximum fractions with pure target protein. This study successfully produced anti-thyroglobulin nanobody which can be further explored for its thyroglobulin binding ability and applications in thyroid cancer.

Name : Rickson V. V. (188620)
Institute : Centre for Excellence in Basic Sciences
Guide : Dr. Jacinta D'souza
Project title : Characterization of Flagellar Associated Protein FAP147 mutant of *Chlamydomonas reinhardtii*
Abstract : Important biological activities such as motility, signaling, sensing, etc. are carried out with the help of cCilia/fFlagella. The motile ciliuma having a '9+2' axonemale structure obtains its driving force through dynein (situated in the outer and inner dynein arms), which itself is operated and regulated through a complex network of proteins anchored on to respective scaffolding proteins situated within the nexin-dynein regulatory complex (N-DRC) radial spoke (RS) and central pair apparatus (CPA). Till date, the CPA is the least studied molecular complex; around 673 different proteins are found to be associated with itcentral pair apparatus and, their localization within it remains elusive. The CPAcentral pair apparatus of the model organism *Chlamydomonas reinhardtii* contains a scaffolding protein namely AKAP240 (situated within the C2 microtubule) to which multiple proteins are anchored and one such protein is FAP174 (MYCBP-1) which binds to AKAP240 via the RII D/D domain. Previous characterization studies done with FAP174 protein indicated its interaction with several different proteins like FAP147 (MYCBP-AP), FAP75 (Adenylate Kinase), FAP70, etc. and considering the fact that fap174 mutant lack motility, suggest that this protein complex may have a major role in regulating flagella motility.The current work aims at characterizing fap147 mutant (lacks FAP147 which is one of the interacting proteins of FAP174) using two different

approaches - — the mutant approach and using the anti- FAP147 antibody for co-immunoprecipitation. In -silico analysis was carried out in order to predictunderstand the structural, functional and evolutionary featurecharacteristics of the FAP147. For the biochemicalurther characterization of fap147 mutant, was carried out using different techniques such as Western blotting, Far western blotting were used; this also to in order to study the effect of FAP147 mutation on other proteins such as FAP75, FAP174. Molecular cloning of aAntigenic fragments of FAP147 was performed using pET28a plasmid. In -silico analysis showed that the protein contains multiple domains and the secondary structure mainly consists of alpha helix. Phylogenetic analysis indicated that FAP147 protein is evolutionary closer to the algal lineage. Western blotting showed the presence of FAP174 in the axoneme of fap147 mutants. These findings along with additional data would help us in understanding the molecular mechanism behind flagella motility to some extent.

Teaching staff

From left to right:Pradnya Gogte, Pampi Chakraborty, Miriam Stewart, Sangeetha Chavan, Karuna Gokarn, &Aparna Talekar.

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Class of TY (Microbiology-Biochemistry)
2018-2019

MSc Part-1 2019-2020

MSc Part-2 2019-2020

Class of FY (Microbiology-Chemistry-Zoology/Physics)
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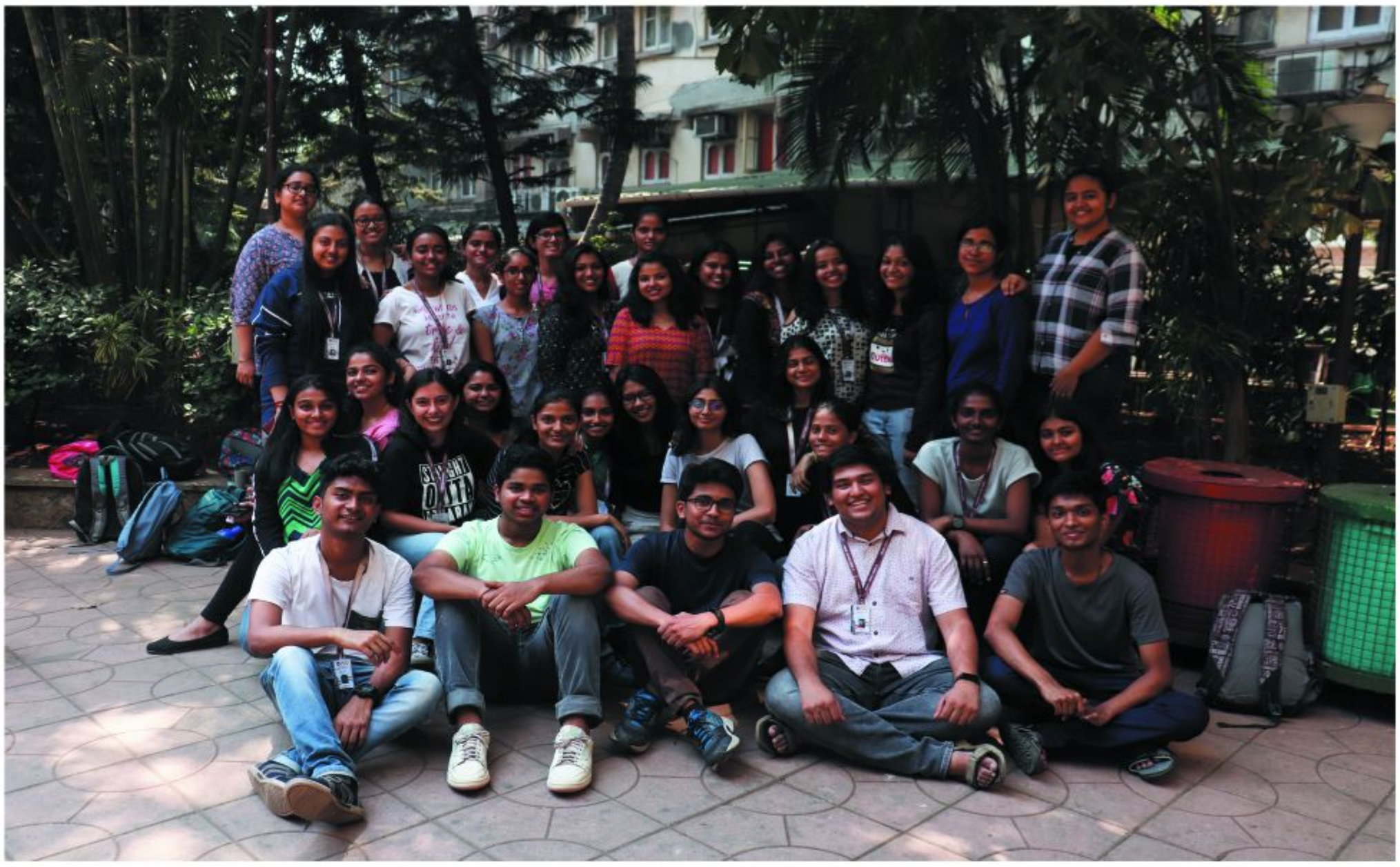

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