

LIGNUM VITAE



Department of Life Science and Biochemistry
St. Xavier's College, Autonomous



EDITORIAL

Jinali Mody.

“We can't solve problems by using the same kind of thinking we used when we created them.” - Albert Einstein

In our world, there has been a great shift from the old-school disciplines to a multi-disciplinary approach at innovation. The problems that plague our world today transcend age, disciplines and geographic boundaries. These problems require a multi-faceted interdisciplinary approach to bring them to conclusion.

Today we see physicists answering questions of DNA structure, musicians engaging in cave archaeology by studying acoustic patterns and forensics scientists using genetic tools to solve crime. This is the future. To get effective answers for questions that our generation pose, the collaboration between individuals from different fields is critical.

Understanding the need for a shift from traditional thinking to the interdisciplinary approach, we at Lignum Vitae have chosen the theme for this year's magazine to be “Through the Looking Glass.” We are encouraging individuals to look at the field of Biology through the perspective of other disciplines. Simultaneously we invite students to look at other fields through a biologist's viewpoint. This revolutionises our thinking process, allowing us to be creative and innovative. Along with broadening our perspective, it proves for better learning and is critical in the evolution of ideas. We begin posing intriguing questions and finding even better solutions.

In this year's issue, we see students making thought provoking connections between ideas and concepts across varied disciplines. We are looking at the same old glass, but through a new lens.

We are extremely proud to announce that this year's issue is the first magazine of St. Xavier's College that is made completely accessible to the visually challenged. The entire magazine is available in Braille along with an e-version, which is also made blind friendly.

This year, we have received a large number of articles from students with varied disciplinary backgrounds. We are absolutely elated with the response and couldn't be more thankful to our writers.

In our education system today, disciplines shape our departments, our coursework, our majors, our faculty and our viewpoints. We urge you to break away from conventional boundaries and come together with an all-encompassing approach to answer compelling questions. Lignum Vitae, the tree of life, in its 5th issue invites you on an exhilarating, challenging and unconventional journey: “Through the Looking Glass.”

Lignum Vitae, Latin for 'the tree of life,' is incidentally the national tree of the Bahamas. Belonging to the genus *Guaïacum*, the tree is considered to be 'holy wood' in many regions of the world. The tree is symbolic of the all-encompassing nature of Life Science as an avenue of study.

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CONTENTS

	06	BURRSINSPIRE
	08	AMAGIC BEYOND US ALL
	10	WHATISLIFE?
SUMMER OF 69 MILLION YEARS AGO	12	ONPHI, FIBONACCI, PHYLOTAXIS
THE LIGHT AT THE END OF THE TUNNEL	14	INTERSTELLAR LIFE: A REALITY?
#LIKE #COMMENT #SHARE #TAG	16	SILENCE PLEASE!
WEIRD MEDICINAL PRACTICES	18	
	20	
	21	
	22	RAINBOW IRIS
	23	

26 — ARE YOU BEING MONEY PULATED?
36 — GENE AND CULTURE
39 — PSYCHOLOGY AND THE COMMON COLD
40 — MAD GENIUS: THE STEREOTYPE
28 — UNRAVELLED
42 — SCIENCE SUPPORTS TRUMP
INSECTIVOROUS PLANTS

56

BIOWAVES 2017-
ABSTRACTS

30

BIDDING ADIEU TO A
STALWART: DR. RADIYA PACHA
GUPTA

58

THE
DEPARTMENT OF LIFE
SCIENCE AND
BIOCHEMISTRY

48

CURRENT
RESEARCH

44

POLYMER
BASED
NANOCARRIERS: A NEW
FRONTIER IN DRUG
DELIVERY SYSTEMS

52

RESEARCH
PAPER
BY THE STUDENTS OF
THE DEPARTMENT

61

TEAM VITAE:
MEET THE EDITORIAL
TEAM

55

IN
REMEMBRANCE: DR.
DOROTHY
HAKIM

24

MED IN INDIA

46

RIPPED
GENES

62

REFERENCES

BURRS INSPIRE

Hamsa Narasimhan, TYBSc Life Science

“There is a solution to every problem. The only difficulty is finding it.”

Picture this: A problem is presented. You go to an Infinite Storage Facility of Proven Solutions. All you have to do is look carefully. And, hey presto, the solution is found! This magic Facility is right before you - Nature. These solutions are time-tested, the proof being the Living against the mighty odds of Extinction.

Through billions of years of evolution, life forms have developed, adapted, mutated and passed on traits best suited for sustainable survival in a given environment. Fossils remain, recording evidence of Nature’s continual research, experimentation and change.

Humans are not the first life forms faced by a need to develop spaces and processes. The rest of the natural world around us, also has similar needs to fulfil, and has been addressing them sustainably, and with grace and brilliance.

As the name suggests, biomimicry - bio denoting ‘life’ and mimesis meaning ‘to imitate’, is an emerging discipline which looks to Nature for inspiration to address challenges in design, and develop sustainable technologies. At the beginning of every design, the questions asked are “What would Nature do?”, “How does Nature accomplish this function or address this need?” ,“How can we incorporate systems developed by natural predecessors into our designs and use them to tackle problems?”

Although the popularisation of the term ‘Biomimicry’ may be attributed to scientist

Janine Benyus’ book ‘Biomimicry: Innovation inspired by Nature, 1997’, which fuelled the development of this field, Nature has served as inspiration for innovation from as early as the 1500s.

Leonardo da Vinci’s ‘Flying Machine’ stemmed from his observation of birds in flight, and study of their anatomy. Da Vinci’s dream was fulfilled in the early 20th century by the Wright brothers who created and flew the first airplane, inspired by the sight of pigeons in flight.

The science of Biomimicry has since expanded to encompass a diverse range of fields from agriculture and architecture to medicine and energy management.

Velcro was invented by George de Mestral in 1941. Noticing that his dog had burrs on its hide after a walk, he observed that they could be easily removed and reattached. Microscopic study revealed that the burrs had hooks on their coverings which easily adhered to loops formed by his dog’s fur or to threads in clothes. In nature, the hooks on the surfaces of these burrs are a means of dispersal for plants known as ‘epizoochory’, they may be carried away by adherence to animal fur or feathers to new locations. Mestral then developed ‘Velcro’ by creating two complementary fabrics - one with miniscule hooks and the other with loops, which could easily attach and detach from one another. It is now used in a wide range of products, and is an indispensable part of the clothing industry.

Spiders provide us with a wonder material in the realm of Biomimetics - their webs. Spider webs are used by spiders for functions ranging from prey capture and immobilisation to dispersal and as pheromonal trails. They are made of fibrous or globular types of silk, composed of proteins mainly containing non-polar and hydrophobic amino acids made in different glands in the spider's body. They are characterised by flexibility, ability to withstand stress, temperature tolerance, antimicrobial and biodegradable nature and a ratio of strength to density which exceeds that of steel. The composition and intricate patterns of these webs and their properties are a source of inspiration for an abundance of technologies. This 'optimized' system is used to produce lightweight, durable and tough textiles and bullet proof vests. 'Signal threads' in a web are used by spiders to monitor vibrations from afar, as they transmit these vibrations, and provide a quick path for spiders to follow as they move between locations. This phenomenon is now being used by scientists to develop remote sensing and piezoelectric technologies. The webs' sticky nature is also being studied to create biomedical and commercial adhesives which would have the key properties of microbial repulsion and flexibility. Most spider webs also have the intriguing quality of UV reflection. This is used to attract insects, and warn birds away, preventing damage, as birds can detect UV radiation. This property is now being used to prevent the millions of bird-window collisions which occur annually.

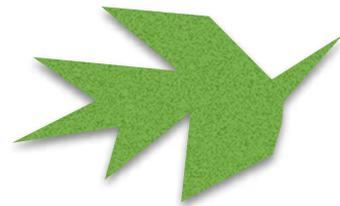
Mosquitoes are inspiring the latest needle designs in the medical world. The unique proboscis of the female mosquito is a highly evolved, intricate structure for blood extraction, which uses biomicroelectromechanical system for painless insertion into the skin using an exceedingly minute amount of force.

One of the most astounding examples of biomimicry in the transportation industry is seen in the Japanese Shinkansen 'Bullet train', inspired by kingfishers. One of



the engineers in the development team, an avid birdwatcher, used his observations of kingfishers swooping into water without splashing to capture prey, to help solve the primary problem of a loud boom which was heard as the train exited tunnels. The kingfisher's streamlined, sharp edged beak was an ideal shape to facilitate movement from a low to high resistance medium without the build-up of pressure waves. These new aerodynamic trains which now operate on 30% less electricity and yet achieve 10% higher speeds move soundlessly through tunnels.

The wrinkles and folds on leaves have inspired major changes in solar cell designs which allow for generation of 47% more electricity from same type and dimensions of their counterparts! The curves on the surface of a leaf function to entrap solar radiation, and serve as a 'waveguide'. These channels greatly increase absorption thereby allowing absorption at the long end of the light spectrum. A leaf's highly efficient network for nutrients and water transport is also being studied to develop 'regenerative' solar cells having longer life spans and composed of more eco-friendly material.



The above are just a few of the several 'ready-made' solutions Nature has provided for us. It is worth noting that the more we move away from Nature towards a man-made world, the more we need Nature to guide us. The guidance is both versatile and benevolent; extremely pragmatic and sustainable.

No organism barring Man fouls its own nest. Man has to realise that Nature has no dustbin. This realisation will aid in making more careful choices regarding what is put into the environment, and the consequences of what is done to the natural world during development. Biomimicry, often called the 'cross pollination of Biology and Design', is a continually evolving science. When used ethically, it will help humankind meet its needs without undermining the inherent sustainability of Life.

A MAGIC BEYOND ALL

Arkanil Roy, SYBSc Microbiology

“Music gives a soul to the universe, wings to the mind, flight to the imagination and life to everything” - Plato.

We are surrounded by music; all we need to do is find it. Some find music in the hammering of a blacksmith, others in the sawing of wood and most of us in vocals and instruments. The commonality is that music is the ultimate relaxant for all of us: it comforts and sustains, reassures and motivates. Music is a piece of art that goes into the ears, and straight to the heart.

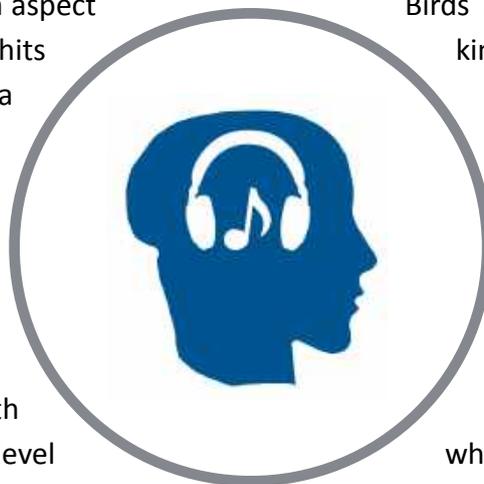
We have all experienced chills when we listen to music. It generally happens when one has associated a certain musical piece to a certain aspect of their life. So, when the music hits the right chords, our body goes on a physiological joyride: the heart rate increases, the pupils dilate, body temperature rises and the cerebellum becomes more active (which would explain why one taps their feet when they hear music). The cerebellum along with the ear, collectively called the low-level processing unit, perform the initial analysis and breakdown of the sensory stimulus that is being heard. The brain then gets filled with dopamine, a neurotransmitter, released due to the stimulation of the reward system of our body which results in the chills. The dopamine flows to the striatum, which is a part of the forebrain that is activated by addiction, reward and motivation. Thus, music has similar effects on our body as drugs, gambling, sex or even potato chips!

Music not only affects humans, but also other animals. Animals too undergo several changes when listening to the appropriate music. Various studies

have shown results that have proved that animals also react to music in ways both similar to as well as different from the way humans react. In laboratories where animal testing is practised, it is seen that different genres of music illicit different response in animals. It was observed that classical music induced sleep in animals, whereas metal led to increase in nervousness, shaking and so on. Comparable results were observed in resident kennel dogs.

Birds are well-known singers in the animal kingdom. In a test aimed to observe how birds react to music, a male and a female white-tailed sparrow were examined, and their reaction was noted to the sounds of other male birds. Both the sexes of birds reacted in a manner similar to human behaviour: the female bird liked the sound of it's opposite sex whereas the male bird disliked it.

The effect of music is very clearly seen in cows. In a test consisting of 1000 cows, various genres of soft and hard music were played to them for 12 hours per day, followed by silence for the other 12 hours, at a stretch for 9 weeks. It was then seen that when exposed to calming music, like R.E.M.'s "Everybody Hurts", Simon & Garfunkel's "Bridge Over Troubled Water " and Beethoven's "Pastoral symphony", the milk produce per cow increased by about 3%.



This was because the calming music reduced stress and consequently led to increased milk production. However, the cows did not respond well to songs like the "Size Of a Cow" by Wonderstuff (I wonder why?).

There are certain animals which do not react to human music, but respond to music which resembles the auditory signals that they use for communication. Cats are rather indifferent to human music. So a few people developed music that would be more "catchy" to cats using the same frequencies and tempos that cats use to communicate. Then they went to various households and played both classical music and this feline music. It was seen that in the latter case, cats came closer to the speaker and rubbed their bodies against them.

Monkeys are seen to be indifferent to human music, so music inspired from the sounds they make was developed. It was seen that when songs inspired by their calming native sounds were played, the animals relaxed and their appetite increased. Conversely, when music inspired by warning noises was played, the monkeys became restless.

Hence, we see that the joy of music is not only restricted to humans. It is universal, bringing about peace to most living creatures, and making their lives better.

"Ah, music."

"A magic beyond all we do here!"

Well said Dumbledore, well said.

SUMMER OF 69 MILLION YEARS AGO

Lynette Dias, SYBSc Geology.

When we feel hot the first thing we do is find a way to lower our body temperature. Depending on what we have at hand we can either wear loose clothes, increase the fan speed, or travel to a cooler region. Even a small change in temperature of 4 or 5 degrees affects us but we can adapt to such changes. That is the reason why humans inhabit 6 of all the seven continents. However not all species are lucky enough to be able to adapt so quickly and hence are found only in certain climatic zones, where their adaptations are seen in their morphology. Plants and corals are the most helpful in this study as they cannot migrate to escape climatic changes and are fossilised *in situ*. Such organisms are invaluable in studying the palaeoclimate of our planet and are used as "climate proxies."

The branch of Palaeontology (palaeo: ancient, onto: life, logos: study) forms the link between Biology and Geology. It deals with the study of fossilised remains of prehistoric life found in sedimentary rocks and from the data obtained, it pieces together the evolution of species, the ecology of the organism, and most interestingly the climate of the past.

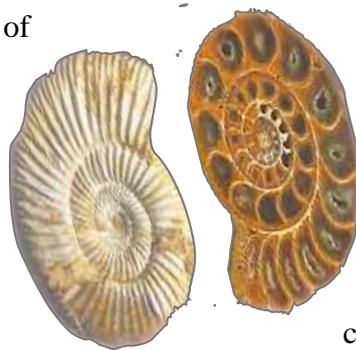
Let us go back a few million years. Consider a fern falls into a swamp and is covered by mud, the absence of oxygen prevents the decay of the fern. As time goes by the swamp dries out and the mud hardens. Through the millennia the fern gets converted into a thin film of carbon which

forms an imprint- a fossil. Coming back to the present, this fossil tells us that the climate in that region was once suited to the growth of ferns i.e. it had a warm tropical climate. One may ask, why do we study the paleoclimate of a region? The answer is simple: a whole swamp full of ferns and other leafy plants got fossilised around 300 million years ago and these fossilised ferns form our coal reserves today, one of our most important energy resources. Therefore studying the palaeoclimate can help locate potential coal deposits!

Although coal formation occurs in tropical regions, it is also found in the coldest ice covered continent on earth- Antarctica. In fact coal deposits are widespread across the Transantarctic Mountains. These deposits contain the fern fossil *Glossopteris*, which we know from age dating techniques lived around 200-300 million years ago. The presence of this fossil fern tells us that during this time, Antarctica had a warm climate where swamps prevailed. A rather interesting fact is that *Glossopteris* fossils have also been found in South Africa, South America, India and Australia. This not only tells us that all these continents had a tropical climate around 200 million years ago but also serves as an evidence for continental drift! All these southern continents were part of one big supercontinent Gondwana and hence had the same climate which allowed the same species of fern to thrive.

Foraminifera and diatoms are shelled organisms found in aquatic and marine environments. They are commonly used climate proxies. Forams shells are made up of calcium carbonate (CaCO₃) while diatom shells are composed of silicon dioxide (SiO₂). When these shelled organisms die, their shells sink to the ocean floor where they are covered with more shells or sediments. Sediment cores from the ocean floor later allow us to study these shells. Oxygen isotope ratios [O₁₈/O₁₆] contained in these shells can give us an idea of the water temperatures in the past. Oceans closer to the equator are warmer and have a higher concentration of heavy oxygen- 18O compared to oceans closer to the poles. This is because water made up of light oxygen evaporates readily. The shells of forams that lived in warmer waters will thus have a higher amount of heavy oxygen than those that lived in cold waters.

A species of forams- *Neogloboquadrina pachyderma* is a great source of information on the sea water temperature due to its coiling pattern. During very cold climates the ocean temperatures drop and this foram species will develop a shell that is coiled in an anticlockwise manner (sinistral coiling). When ocean temperatures rise it grows a shell coiled in a clockwise manner (dextral coiling).



Corals are a group of organisms belonging to phylum Coelenterata that thrive in warm tropical waters. If the water temperature changes by even a few degrees, these corals begin to die. Hence

they are excellent indicators of palaeotemperatures. They are found to grow in a belt between 30 degrees north and south of the equator where the temperatures do not drop below 18 degrees even in winter.

During the formation of the coral skeleton along with calcium carbonate, elements like strontium and calcium are also incorporated into the skeleton. These Sr/Ca ratios can act as very good proxies for changes in water temperature. When ocean temperatures rise, there is a decrease in the Sr/Ca ratio in corals.

From the study of palaeoclimates we can try to predict the effects of global warming and changes in monsoon cycles or variations in ocean circulation like El Niño which have a great impact on our lives and business today.

While palaeontology might be strikingly different from the biological sciences with respect to its study of “dead” organisms, it relies heavily on the comparison between modern life forms and their biological ancestors which tell us a great deal about Earth’s geological history :its climate, ocean bathymetry or composition, evolution of species and so much more.

Today we stand at a critical juncture where preserving our natural resources is the need of the hour. Understanding the reasons behind drastic climatic changes in the geological past shall give us a clearer direction towards sustaining the biology on our planet in the days to come.

DID YOU KNOW?

Sharks require so much oxygen that most species must swim continuously, throughout their lives, in order to keep oxygenated water flowing over their gills.

Sharks that need to keep swimming to stay alive never really ‘sleep’

They simply enter a sleep-swimming stage where certain parts of their brain become less active, while the shark continues swimming.

It has also been seen that some sharks rest by ‘yo-yo’ swimming, where they actively swim to the surface and then rest as they descend.



WHAT IS LIFE?

Karl Poncha, SYBSc Life Science

Schrödinger in his book, 'What is Life?', compares the order inside living cells to the order possessed by non-living systems cooled to absolute zero which exhibit quantum phenomena. Whereas, non-living systems at physiological temperatures work on the principles of thermodynamics.

The question 'What is life?' always seems to elicit a very deep, philosophical or spiritual attempt to answer it. However, the answer is shockingly simple. Physics. Physical phenomena governed by the laws of quantum physics and the laws of thermodynamics are, in fact, the best arguments for life itself. As unremarkable as it may seem, we are thermodynamically favoured systems at the molecular level, at the same time avoiding entropic decay. At a much smaller level, reactions in our cells, especially enzymatic reactions are, in fact quantum phenomena.

So it solicits the question: Does quantum physics give us the answer to one of mankind's most infuriating questions through the ages?

What quantum biologists examine are subatomic particles which, as a consequence of their size or behaviour, follow the rules of quantum physics and not thermodynamics in living systems.

Physicist Jim Al-Khalili follows the sequence: *"Quantum physics gives us how bonds are formed in molecules, and can thus underpin organic chemistry, which scaled up in complexity leads to molecular biology and finally life itself!"*

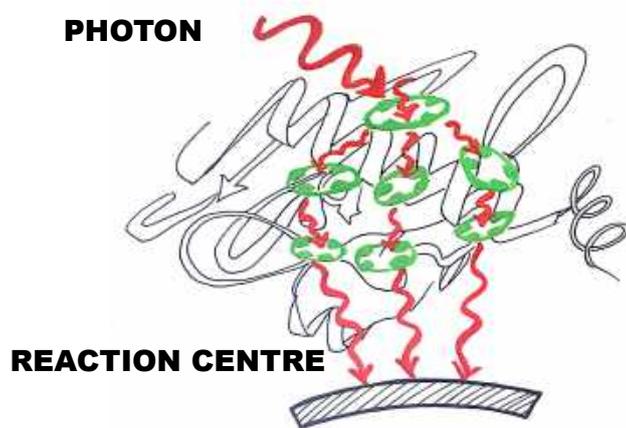
The general consensus has been that quantum phenomena can be disregarded in the cell as when one looks at billions of atoms together, these quantum effects disappear. However, there are several irrefutable evidences of quantum phenomena in living systems.

This is remarkable as these phenomena that physicists study, must be studied under very specific conditions for example, at near 0 K temperatures, in vacuum and inside Faraday cages to prevent any disturbances. Yet, they can be seen so plainly inside living cells.

Quantum tunnelling, an example of the aforementioned trends, is a phenomenon in which particles move through a barrier that they traditionally could not surmount. The best example is that of getting a ball across a wall. Traditionally one would provide the ball with enough energy that it is able to go above the barrier. Quantum tunnelling breaks this rule, i.e. the ball moves through the wall, and the wall still remains intact. This plays a role in several physical phenomena, such as the nuclear fusion that occurs in main sequence stars like the Sun. Quantum tunnelling has been hypothesised to be responsible for DNA mutations such as tunnelling of the protons. Protons constitute the hydrogen bonds, linking one nitrogenous base to another, and change cause by tunnelling could even be responsible for certain DNA mutations, causing cancer.



Another example of quantum phenomena is quantum coherence where a quantum particle does not behave like a particle, but as a wave and thus is not confined to a single path, but can move along multiple paths in a spread-out fashion simultaneously. This has been shown to take place in bacteria carrying out photosynthesis, where the photon captured by a chlorophyll molecule is delivered to the reaction centre by coherence, i.e. following multiple pathways. This has been found to be the most efficient and optimum path of the photon by which it avoids getting dissipated as heat.



It is speculated that both these phenomena play a role in a process we all know very well - the electron transport chain of aerobic respiration linked to ATP production. Here, long-range tunnelling of distances of 15-30 angstrom have been observed, when electrons are transferred from one redox carrier to another, despite huge separation. Thus the tunnelling has been found to be temperature independent but distance dependent. The energy of the electrons also do not get dissipated as heat – hence, research is being carried out to check if this is also due to coherence.

Furthermore, decoherence may occur through bypasses such as thermogenin in hibernating animals leading to heat production. Thermogenin, a transmembrane protein found in the mitochondria of brown adipose tissue, is responsible for stopping the production of ATP in the mitochondria by allowing protons to 'leak' in

through the inner mitochondrial membrane and hence getting dissipated as heat. This is thought to be a consequence of decoherence.

Perhaps the most interesting and exciting research that is happening is on quantum entanglement. Quantum entanglement is a phenomenon in which groups of particles are interlinked such that the quantum state of an individual entity cannot be described independent of the rest of the system, even when separated by a significant distance. Thus, only the quantum state of the system as a whole can be described.

It has been known for very long that several species of animals migrate using magnetoreception i.e. navigation using the earth's magnetic field. However, the mechanism of the same is still unknown. The only theory put forward is that of quantum entanglement. When light of suitable wavelength enters the retina of a bird, it excites an electron in the chromophore-cryptochrome. This electron is entangled with another, which means they are in phase. This entangled system is highly sensitive to fluctuations in the earth's magnetic field. Perturbations of this entangled system is thought to create biochemical products that govern directional navigation through signal transduction pathways.

It is quite evident that quantum phenomena are perhaps the very functional units of life processes. Further research could tell us if the 'net sum' of these phenomena could relate to the thermodynamic equivalent determined in cells. It could also help us to explain processes like the electron transport chain from a different and more contemporary perspective which, is less deterministic and rigid than previous theories and can even account for the 'randomness' we see as part of the uncertainty of quantum entities.

Thus further research into the many more quantum phenomena speculated to occur within cells could one day help us grasp at the question '**What is Life?**'

The light at the end of the tunnel

Surpreet Bhasin, FYBSC life science



Biology is believed to be the crucible of life ever since its inception. This subject involves the myriad of aberrancies that people are born with or become victims of, blindness being one of them. It is the duty of the visually abled to make life less challenging for our sightless companions and to bring them at par with the other members of society. Countless doctors, researchers, common civilians, governments and non-government organizations are committed to this cause, and are striving to make the world a better place for the blind. Owing to scientific developments, it is likely that every affected individual will soon be able to see the light of day.

There is newfound hope for the visually challenged as scientists at the University of Southampton, England, have discovered stem cells in the human eye that have the potential to metamorphose into light sensitive cells, which could reverse blindness. In the words of Professor Andrew Lotery, a consultant ophthalmologist at Southampton General

Hospital, "These cells are readily accessible, and they have surprising plasticity, which makes them an attractive cell resource for future therapies."

According to scientists, implanting the cultured stem cells in an impaired eye could help cure 'macular degeneration' (which causes damage to the macula of the retina) as well as 'retinitis pigmentosa', (which affects the ability of the retina to respond to light). These conditions are caused by the loss of photoreceptor cells in the eye, which leads to blindness. Professor Lotery's study focuses on stem cells extracted from the patient's corneal limbus (which is situated at the border of the cornea and the sclera or the white region of the eye). These cells can be cultured in the laboratory and transformed into photoreceptor cells, which are implanted back into the eye of the same patient, thus avoiding complications due to rejection.

These stem cells are found in all people, irrespective of their age. Thus, this treatment could be a huge success as it has the potential to treat Age-re-

lated Macular Degeneration (AMD), one of the leading causes of blindness.

This concept has been proven to work in the laboratory; however, scientists are yet to transplant these photocells in a human patient. There is a belief that this approach will be brought into operation within the next four years.

Another discovery by Dr. Ahmed Nagiati El- Amir, an England based ophthalmologist, involves a technique that uses a series of lenses which when inserted into the eye, enlarge the image formed on the retina. This image is then picked up by the brain from the healthy parts of the retina, resulting in normal vision. This technique involves numerous scans of the eye to understand its anatomy, which is unique from person to person, and uses different ways to support the lenses once they are implanted into the eye. This is a personalized treatment that caters to each patient's individual needs.

Special contact lenses, developed at the Swiss Federal Institute of Technology, have in-built telescopes that increase peripheral vision three-fold. This invention could help individuals suffering from peripheral sight loss, with daily tasks such as driving and reading and thereof gain some independence. The lens would be made available by 2018 and its use is safer and cheaper than surgery.

An alternate technique that does not restore sight but combats the major disadvantages faced by the visually challenged is HandSight, a device developed at the University of Maryland. This device enables users to read with the help of a tiny camera placed at the tip of their fingers. When attached to

the fingertip, it directly translates written text into speech. In order to read printed material that is not written in Braille, users are required to move their fingers along the text. This text is read by the device and is simultaneously dictated to the user by computerised software. Phonic hints and haptic buzzes assist users in making their way through the text and ensure that their finger is positioned on the line. This technology promises the inception of more dynamic devices in the future that might also offer perception of other visual characteristics like colour and pattern.

The quest to end blindness, once and for all, has begun. The Sanford and Susan Greenberg Prize to End Blindness by 2020, is a reward worth \$3 million, that will go to the individual, group or institution that is instrumental in ending blindness by the end of this decade. The purpose of this prize is 'to create a worldwide research community that will contribute its collective skills and resources to end blindness forever as the scourge of humanity.'

Perhaps, a long cherished dream to enable the blind to envision the world and their life ahead, is very close to its fulfillment. There is much truth in the old saying, 'there is always light at the end of the tunnel,' and that light is becoming brighter with every passing day.

DID YOU KNOW?

By the age of eighteen your brain stops growing.

From that age forward it begins to lose more than 1,000 brain cells every day.

Only two percent of your body weight is occupied by your gray matter, but it uses up to 20% of your overall energy output (it needs carbohydrates).

Babies born with farsightedness. They start to focus properly only between 3 to 6 months of age.

ON PHI, FIBONACCI, PHYLLOTAXIS

Shalom Palkhivala, TYBSC Physics

What do ancient Greeks and *aloe vera* have in common?

The answer is that they both exploited a number known as the Golden Ratio (ϕ), which is approximately 1.618... It is also interestingly defined by the continued fraction

$$\phi = 1 + \frac{1}{1 + \frac{1}{1 + \frac{1}{1 + \dots}}}$$

and is the ratio of two quantities if their ratio is equal to the ratio of their sum to the larger quantity.

When, in 447 BC, Phideas *et al* designed the Parthenon – a temple dedicated to Greek goddess Athena – the Golden Ratio was observed in the dimensions of many structures within the temple. But while it may seem to be an arbitrary mathematical construction, ϕ pervades not only the man-made world, but that of nature as well.

Leaves are not arranged around the stem of a plant in a random manner, but according to a precise arrangement. More often than not, ϕ has an important and critical role to play. In order to maximise the exposure of leaves' to sunlight (i.e. minimise obstruction caused by upper leaves), many plants, like the *aloe vera*, shun a periodic arrangement, opting instead for an arrangement wherein the circle (360° around the stem) is divided by an irrational number of leaves. With ϕ being highly irrational (it excels at not being expressible as a fraction), the angle between the leaves is $360^\circ/\phi = 222.5^\circ$, which is the conjugate angle of 137.5° – the "Golden Angle." (When you take the ratio of these two angles – $222.5^\circ/135.5^\circ$ – the result is none other than the Golden Ratio again.) You

can check for yourself that the black and the white lines superimposed on the specimen in the picture form angles very close to 137.5° – and that the *aloe* had adopted the Golden Ratio hundreds of millions of years before Phideas was born!

Who would have thought that at the heart of every pinecone in a pine forest lie Fibonacci numbers and the Golden Ratio? The characteristic spiral made by the scales on the cone is so arranged to maximise the number of scales in the available area, and the tree accomplishes this by rotating each successive scale in the spiral structure by 0.618 of a circle each time: If a rational fraction of the circle were used (for instance, each scale being turned by $\frac{1}{4}$ of a circle), this would lead to the spiral branching away from the centre of the cone (in this case, in a + sign), leaving gaps in between; hence, the Golden Ratio provides the optimum packing scheme for the pinecone's scales, minimising wasted space between scales.



But if you count the number of spirals on a pinecone (one is highlighted above), the result will generally be a Fibonacci number; in fact, the number of clockwise and anticlockwise spirals is consecutive in the Fibonacci series. The same applies for sunflower seeds and pineapples. This remarkable fact suggests that ϕ is not the only parameter governing phyllotactic

arrangement and the placement of seeds. The plot thickens...

The Fibonacci series is a series of numbers in which each number is the sum of the previous two. Equivalently, the sides of the squares making up the "Fibonacci spiral" alongside have lengths that are Fibonacci numbers.

It's no surprise then that the Golden Ratio and the Fibonacci numbers are so intimately connected both in mathematics and in nature. As we take the ratios of two consecutive Fibonacci numbers higher and higher in the series, *voilà!* the result converges to φ . (This is evident from the spiral shown above: the sides of the squares are consecutive Fibonacci numbers, and their ratios approximate φ .)

These numbers (1, 1, 2, 3, 5, 8, 13, ...) show up time

and again in nature. Many flowers have a Fibonacci number of petals. Mollusc shells, human cochleae and the horns of sheep form Fibonacci spirals. The lengths of the sections of a human finger are in the proportion of Fibonacci numbers. Even the humble cabbage has, through a process of self-organisation, arranged its leaves in a Fibonacci spiral!

It seems clear now that both, φ and Fibonacci numbers are far from the man-made mathematical concept, which they are often understood as, and instead are integral parts of nature, providing a blueprint for the architecture of life.

INTERSTELLAR LIFE: A REALITY?

CHRISTABELLE RAJESH, SYBSC LIFE SCIENCE

Isn't it absolutely astounding that there are trillions of stellar systems in the universe, yet life only occurred on one of them? Throughout the years the subject of life outside Earth has transitioned remarkably from science fiction to factual science. At the moment, life on Earth is the only known form of life in the universe, even though there are many arguments that suggest otherwise. This debate leads us to the crucial question: **"Are we alone in this universe?"**

Water is the most fundamental ingredient needed for life on Earth but does it necessarily have to be the case throughout the ever expanding universe? It has been established that some sort of liquid must be present for the growth of life and liquid ammonia or methane oceans on Saturn's moon - Titan, can be promising candidates. Though they may be poisonous to us earthlings, they can be prerequisites for alien life forms.

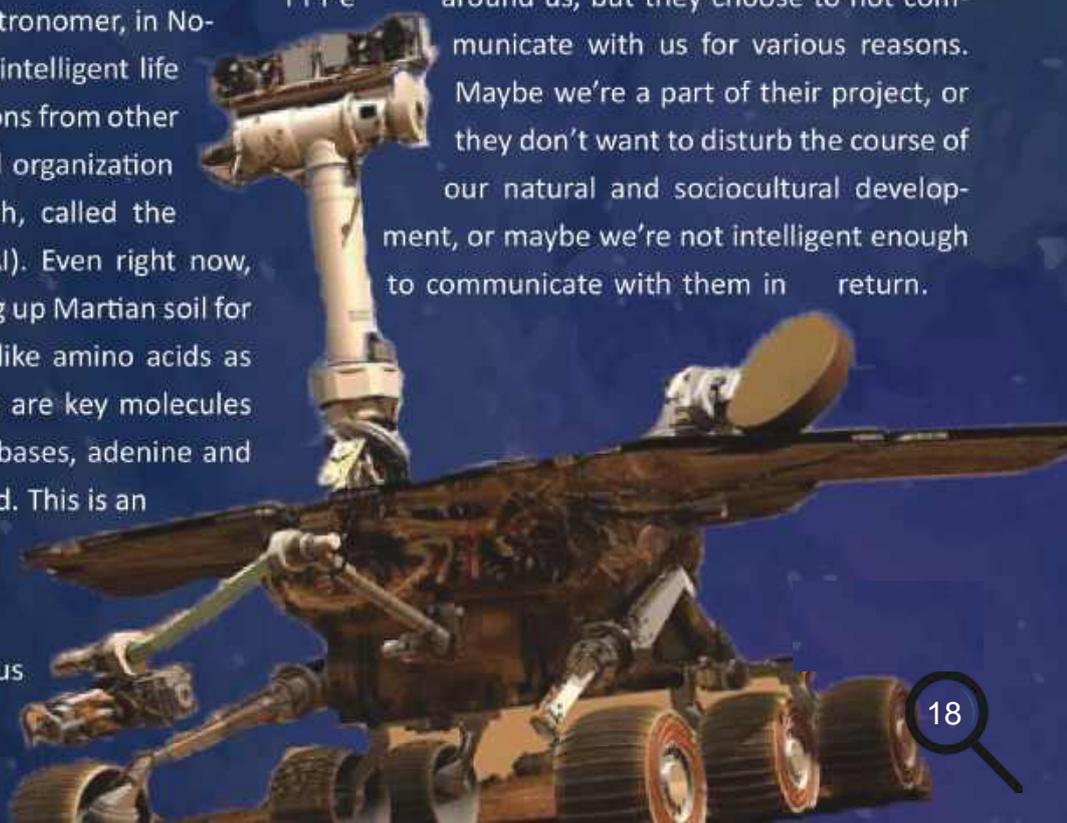
The Search for Extraterrestrial Intelligence (SETI), initiated by Frank Drake - a radio astronomer, in November 1961, aims at detecting intelligent life by 'listening' for radio transmissions from other star systems. NASA has a special organization for astrobiology related research, called the NASA Astrobiology Institute (NAI). Even right now, NASA's 'Curiosity Rover' is digging up Martian soil for samples of organic compounds like amino acids as well as nitrogenous bases which are key molecules found in DNA. Two nitrogenous bases, adenine and guanine, have already been found. This is an indication that there is potential for life.

Furthermore, astrobiologists focus

on the thousands of Sun-like stars, within a hundred light years of the Sun. NASA's Kepler space telescope has already taken numerous pictures of sun-like stars and their systems. Many of these pictures show planets located at just the right distance from their sun in order to be habitable. On April 17, 2014 an earth-like exoplanet called 'Kepler-186f' was discovered which is at a distance of 490 light years from Earth. This discovery made the possibility of the existence of life outside earth even more real.

Many hypotheses and cosmic theories attempting to explain or prove the existence of extraterrestrial life have been developed over the course of time. The Fermi Paradox is one such hypothesis named after physicist Enrico Fermi. It is a contradiction between the evidence found and the probability of existence of alien life forms. It is an argument about intelligent life being "common" in the universe even after lack of evidence for the same.

The Zoo Hypothesis says that there is extraterrestrial life around us, but they choose to not communicate with us for various reasons. Maybe we're a part of their project, or they don't want to disturb the course of our natural and sociocultural development, or maybe we're not intelligent enough to communicate with them in return.



The Rare Earth Hypothesis, on the other hand, suggests that the origin of life and the evolution of biologically complex organisms, is the result of a perfect combination of astrophysical and geological events, and that it is quite impossible for such an event to occur again in all of time, and hence this leaves us alone in the universe.

Stephen Hawking, in his lecture “*Life in the Universe*” said, “One possibility is that the formation of something like DNA, which could replace itself,

is extremely unlikely. However, in a universe with a very large, or infinite number of stars, one would expect it to occur in a few stellar systems, but they would be widely separated.” Although we may not have solid proof to support the various hypotheses put forward by several scientists, there is a possibility that humans might actually encounter extraterrestrial life forms, and if and when we do, life will, without a doubt, change forever.

GOTTA CATCH 'em ALL

Based on an idea by Anish Ittoop

Pokémon is really great at getting people interested in evolution. Evolution is the process where organisms develop over time. In Pokémon ‘evolution’ occurs when a Pokémon converts into a more powerful creature. Biologically, this is metamorphosis not evolution. Metamorphosis and evolution both involve a change taking place, which is why they are easily confused. The difference is that while evolution happens through a series of genetic mutations over many generations via a process called natural selection, metamorphosis is the process of change in the body structure of an individual that happens once in a life time. The most common real world example of metamorphosis is a caterpillar turning into a butterfly. However, in the Pokémon world, they don’t make a cocoon around themselves. Instead, the Pokémon flash a light, make a beep like noise and voila! ‘Evolution’!

Lets talk about Eevee, a special Pokémon, because it has the most number of ways it can evolve. Need a Flareon? Give Eevee a firestone. Want an Espeon? Make Eevee very happy and level up during the day. Leafreon? Level up near a mossy rock. But can an organism in the real world metamorphose into so many different creatures? The answer is yes. This phenomenon is known as polyphenism. Polyphenism is a kind of

polymorphism where different forms of an animal result from a single genotype. Butterflies are an example of seasonal polyphenism in the real world. Seasonal polyphenism, in layman’s terms, means a single set of genes in a butterfly’s DNA can give rise to more than one type of coloured pattern on its wings. The most well-known of all butterfly species that exhibit polyphenism is *Bicyclus anynana*, also known as squinting brown bush butterfly. During rains, these butterflies have large, conspicuous, concentric rings (eyespot) on their wings but these markings can barely be observed in the dry seasons.



It is rather odd that the designers decided to call it ‘evolve’ and not metamorphosis but its probably because ‘evolution’ is catchier and more suited for the targeted age group. But this sloppy terminology has caused many misconceptions. Hopefully, you’ve learned some Poké-biology and you’re less confused.

#LIKE #COMMENT #SHARE #TAG

**Bernadette Braganza,
TYBMM**

Facebook, Twitter, Instagram, Pinterest, blogs, and a lot more...we live in a world dominated and influenced, to a large extent, by social media. But do you know what all these online interactions are doing to your brain? Well, a lot.

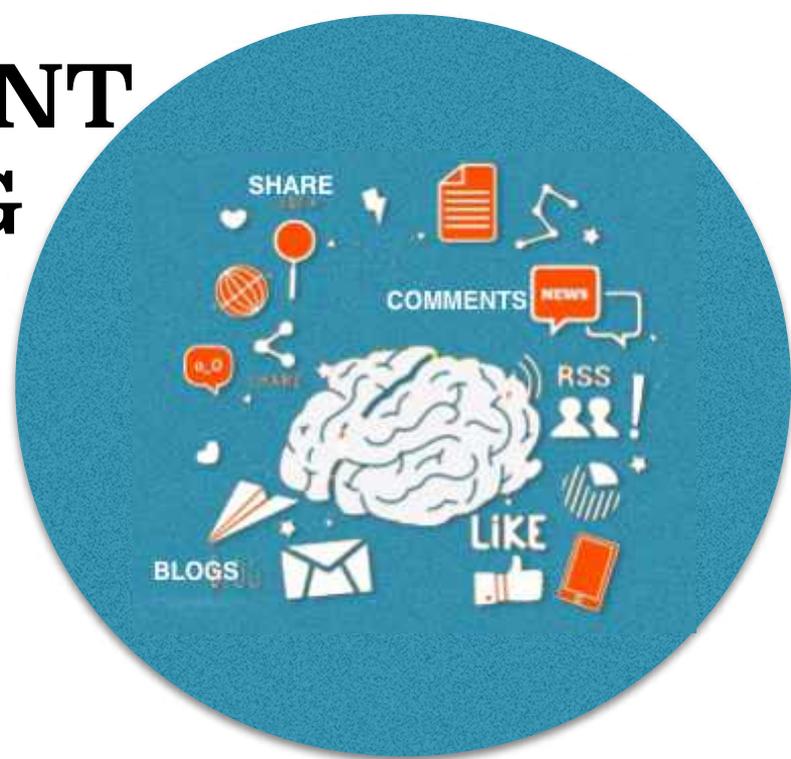
For starters, when researchers Tracy Packiam Alloway and Ross Geoffrey studied MRI scans of students, they discovered that social media tends to work wonders in improving the working memory. Any muscle in the body, when exercised, tends to get stronger. When a person is constantly faced with a lot of information, the brain gets exercised by the amount of information it is absorbing and memorising. Thus, status updates, pictures, videos, and other such information exercise the brain and improve its working memory.

On the flip side, social media also causes a reduction in attention spans. When a person is sitting with a number of social media sites open in front of him, his mind keeps shifting from one site to another. This reduction in the attention span does not give the brain enough time to absorb or retain the information it is reading or viewing. It is for this similar reason, that when some people try to multi-task, their productivity levels tend to plummet.

Chemically, there are a lot of changes taking place in the brain. When people view the 'likes' or positive comments their posts get, the reward sections of the brain, particularly those in the nucleus accumbens, get activated. Excessive use of social media tends to increase the levels of dopamine and oxytocin that our bodies produce.

Oxytocin is a chemical secreted by the pituitary gland located at the base of the brain. According to Paul Zak, a neuroeconomist and author, oxytocin is known as a type of 'social glue', which tends to increase emotions such as generosity, empathy, trust, and sharing. It also causes some posts to go viral, especially the ones that trigger concern and compassion.

Dopamine, which is released in different parts of the brain, is a neurotransmitter which controls the pleasure



and reward sections of the brain, among other functions. It is the chemical which gives the 'high' upon the consumption of both drugs as well as chocolates, and causes a calming and pleasurable feeling. A like or a comment on a picture often causes a release in dopamine levels and that is how we get addicted to social media.

The saying that, 'man is a social animal' has its basis not only in the social sciences but also in biology. The dorsomedial prefrontal cortex of the brain is responsible for making us see the world through a social lens. Loneliness, stress, and boredom act as a trigger to make a person check social media posts.

Social media can also trigger some parts of the brain to function as a replacement to certain situations. For example, according to researcher Matthew Lieberman, the brain network which lights up while taking a break, is the same one that works while you are checking your social media newsfeed. So, whenever you want to take a break from a difficult task, you may actually end up checking your Facebook or Twitter news feed.

This cycle of likes, comments and shares keeps going on with different sections of the brain constantly getting triggered and resulting in people using social media to keep anticipating that 'high' it gives. It is all these things that cause people to keep checking their news feeds and social networks all the time. In some extreme cases it causes Internet Addiction Disorder (IAD), where a person's internet usage becomes so compulsive that it interferes with his/ her normal life

So, the next time you open your phone to check your news feed, do remember the ways in which social media is affecting your brain.



SILENCE PLEASE !

Kriti Rajda, FYBSc Life Science

I moved to Mumbai a few months ago, and one of the things that jumps right at you, is the noise. You can't escape it. The traffic, the construction, and the festivals add to a constant background racket in the heads of all residents of this city. The twisted irony is, noise-cancelling headphones, which blare noise directly into a person's ears, have become a way to get 'peace and quiet'. Most of us have forgotten what true silence really is and the only way to drown out noise, is with more noise.

Until the 1970s, noise was merely viewed as a 'nuisance' rather than a legitimate form of pollution. Excessive noise has been found to cause aggression, hypertension, hearing loss, sleep disturbance, and even tinnitus. In fact, these ill effects have been observed as far back as 1859, when Florence Nightingale wrote, "Unnecessary noise is the most cruel absence of care that can be inflicted on sick or well."

This is, of course, not very surprising. However, what is surprising is that silence actually has positive effects on human brains, as well as on those of other species.

In most studies concerning effects of noise, subjects exposed to silence were used as a 'control group' and were expected to show no net positive or negative results. However, in general, the control group was observed to be better off than any other group exposed to noise.

One example of this was a 2006 study published in the research journal *Heart*, by physician Luciano Bernardi. This study aimed to assess the cardiovascular, cerebrovascular, and respiratory changes induced by different types of music in musicians and nonmusicians. One of the interesting results of this study was that in the 'rest periods', or the times when the subjects were

exposed to silence, their heart rate and blood pressure decreased to rates even below the expected base level. It was thus found that the rest periods induced even greater relaxation in the test subjects than the music that was supposed to be 'relaxing'.

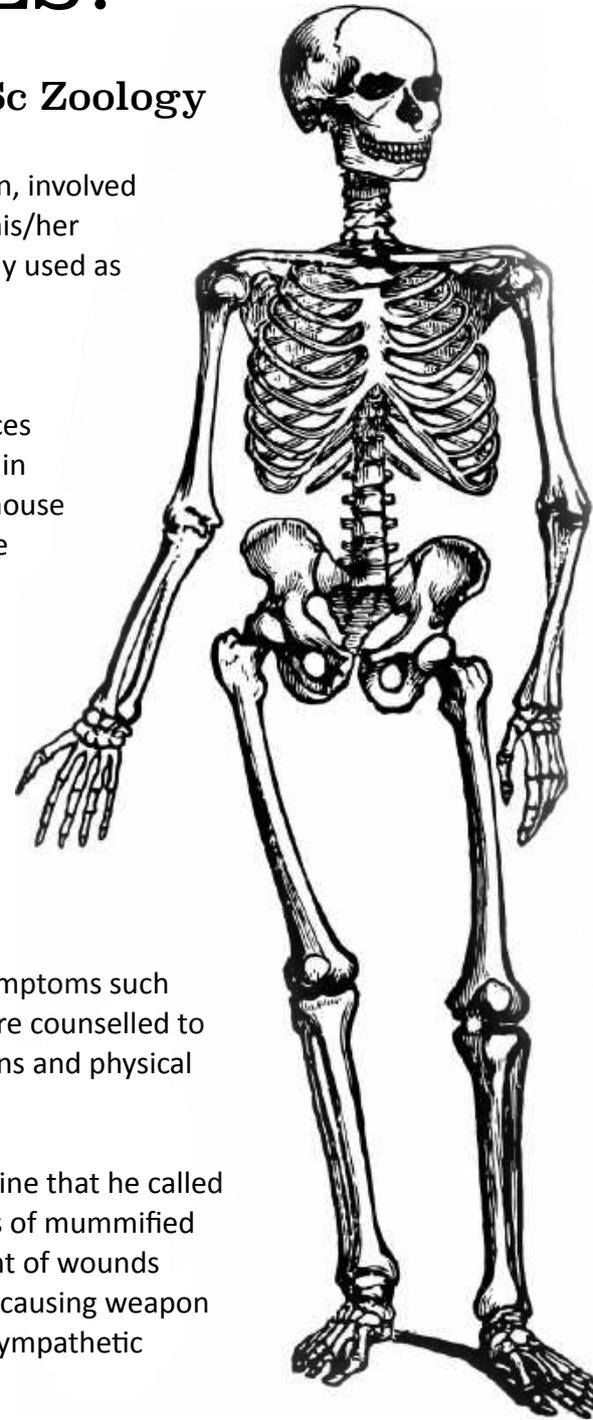
Another such study was conducted by Imke Kirste, a regenerative biologist at Duke University, in 2013. She was studying the effects of various types of noise on the brains of adult mice. Four groups of mice were exposed to different types of sounds, such as music, baby mouse calls, white noise, and silence. Kirste expected that baby mouse calls might stimulate brain cell development in adult mice, while the group exposed to silence was assumed to be a control group. While all the other groups exhibited short-term neurological effects, none of them had any pronounced, lasting impact. However, she found that exposure to two hours of silence a day prompted neuron development in the hippocampus, the region of the brain concerned with memory and sensory development. This was a surprising result, since a lack of external stimuli appeared to have longer-lasting effects than any actual stimulus. Kirste reasoned that the total absence of sound was an 'artificial' environment to the mice, which stimulated the development of new cells.

Since the benefits of silence are only now being widely recognized, it is actually starting to be marketed as a commodity. A report published on Finland in 2011 highlighted a host of themes out of which the most interesting one was silence. In today's 'intolerably loud and busy world', the Finnish tourism board released a tourism campaign with the slogan 'Silence, Please'. Now, this slogan is one of Finland's main allures. A Finnish watch company, Rönkkö, launched a new slogan as well: "Handmade in Finnish Silence." The Finnish government, by monetizing silence have, quite literally, made something out of nothing. If only other countries followed their example, the world would certainly be a much quieter place.

DID YOU KNOW ABOUT THESE WEIRD MEDICINAL PRACTICES?

Isha Shyam, SYBSc Zoology

- The oldest form of surgery known to mankind, called Trepanation, involved the practice of boring holes into the skull of the patient to cure his/her illnesses. Trepanned skulls from Peru showed that it was probably used as a method for cleaning bone fragments from skull fractures.
- The Egyptian civilisation was the first to have a structured and hierarchical medical profession but some of their medical practices were quite bizarre. One such practice was placing a dead mouse in the patient's mouth to cure toothache. Many a times, mashed mouse mixed with a few herbs was used as a poultice and applied to the affected tooth.
- The Egyptians made use of animal excreta in various ointments. Dung of animals such as donkey, dog, gazelle etc. was often used in ointments, as they were believed to ward off bad spirits. Crocodile dung was used as a contraceptive.
- Some ancient Greek doctors held the belief that a woman's uterus was a separate entity from her being. According to them, if a woman was celibate for a long time, her womb could dislodge and move about her body freely, causing a variety of symptoms such as hysteria, seizures and suffocation. To prevent this, women were counselled to marry young and bear many children. Therapeutic baths, infusions and physical massages were prescribed.
- During the Medieval times, Sir Kenelm Digby discovered a medicine that he called the 'Powder Of Sympathy'. Made of pig's brain, earthworms, bits of mummified corpses, rust and ground into a powder, it was used for treatment of wounds inflicted by rapier swords. The powder was applied to the injury-causing weapon instead of the injury itself. Digby thought that a process called 'Sympathetic Magic' would cause the wound to heal itself.
- A remedy for gout suggested that an owl be plucked, opened, cleaned and salted. It was then to be placed in a new pot with a stone and put in an oven till it burnt. It was then to be pounded with boar's grease and anointed on the gout.
- In the middle ages, Black Death was believed to be caused by "deadly vapours". Some doctors, in order to combat these vapours, suggested the use of foul smells to keep the disease at bay. One way to do so was to store flatulence in jars. Each time the deadly pestilence appeared in the neighbourhood, people were to open the jars and take a whiff.



RAINBOW IRIS

Clarita Mendes, FYBSC Zoology

Ever wondered why irises vary in such a magnificent array of colours? The colour of an eye depends on the number of melanocytes present in it and whether they are active or not. These melanocytes contain melanin (also found in hair and skin) and derivatives of melanin such as eumelanin which shows brown or black colouration and pheomelanin which shows orange to yellow colours. If the iris contains a lot of melanin, the eye appears to be brown to brownish-black. As the amount of melanin decreases, the colour of the eye moves from a range of shades of hazel to green to blue. The shades of green and blue



are due to the presence of lower melanin concentration in the iris.

People with albinism often seem to have red eyes. Here, due to a lack of pigment in the iris, the light enters and reflects off the blood vessels present at the back of the retina, giving the eyes their red appearance.

Eyes have the ability to change colour, in both humans and animals, during the first few years of infancy as the melanocytes develop to produce melanin during this time. Kittens have blue eyes when they are born, which often changes into another colour after a few months of their birth. There is also a possibility of change in eye colour during puberty or childhood due to demelanization of the iris.

med in india

Anant Venkatesh, FYBA History

Studying life sciences, from a chronological perspective, involves scrutinizing the evolution of thought and behaviour as well as the human race's increasing respect for life. Thus began our revolutionary quest of prolonging life span, curing diseases and deformities and decreasing mortality rates. These advances fuelled man's quest for knowledge and laid the foundation for further research in medicine and other natural sciences.

History is no different from the strata of sciences dealing with life. We find both disciplines centred around living organisms and the study of change, stability, resilience, and reform.

Although modern science could trace its roots to all the great civilizations of the bygone era, the contribution made by ancient India to science is perhaps the most significant. Unlike any other contemporary development elsewhere, the importance placed upon knowledge, schooling, education and erudition by our ancestors remains distinct.

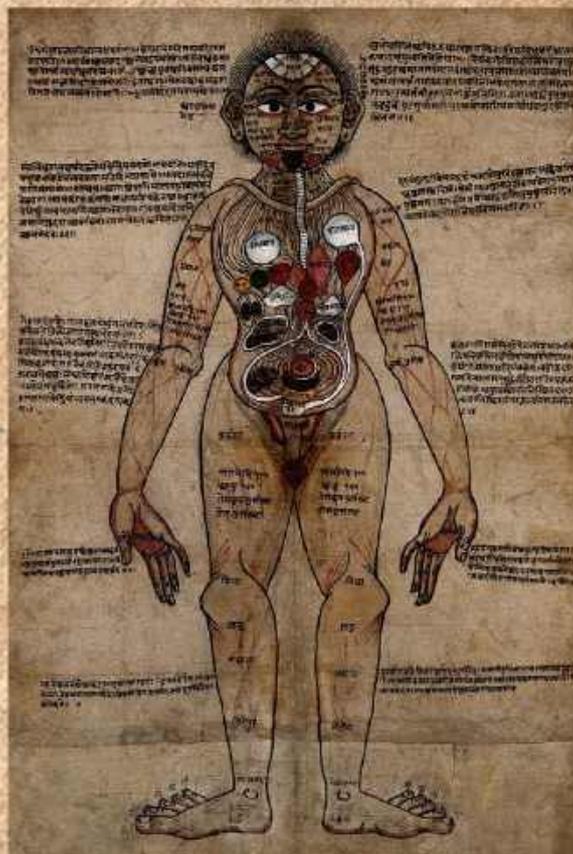
Ayurveda, originating from the Atharva Veda, is the medieval precursor of life science. Etymologically, "Ayurveda" translates to "knowledge of life" or "the science of longevity". Long before the birth of Hippocrates, Charaka authored a foundational text, the Charaka Samhita, on the ancient science of Ayurveda. Referred to as the Father of Indian Medicine, Charaka was the first physician to present the concept of digestion, metabolism and immunity in his book. His ancient manual on preventive medicine remained a standard work on the subject for two millennia and was translated into many foreign languages,

including Arabic and Latin. Ayurveda has evolved over five thousand years, and is still practiced today. In an internationalized form, it is thought of as complementary or alternative medicine.

When it came to a highly complex branch of life sciences – surgery, India did not lag behind. The Sushruta Samhita, written in 600 BC, was one of the first texts that explained reconstructive surgery. The system of punishment by deforming a miscreant's body or the deformities and scars inflicted upon bodies during war or training may have led to an increase in demand for this practice. Sushruta is commonly known as the father of surgery due to his work on revolutionary medical techniques that inspired a lot of modern medical procedures. Sushruta Samhita is considered to be one of the most comprehensive textbooks with topics ranging from various illnesses, cures and surgical procedures to the preparation of complex medicinal herbs. The Sushruta Samhita's most well-known contribution to plastic surgery is the reconstruction of the nose, also known as rhinoplasty. Rhinoplasty involved an ingenious technique

which included using a severed flap of skin from the person's cheek, in order to reconstruct the nose or even the ear. The portion of the nose to be covered should be first measured with a leaf. Then a piece of skin of the required size should be dissected from the living skin of the cheek, and turned back to cover the nose, keeping a small pedicle attached to the cheek. The part of the nose to which the skin is to be attached should be made raw by cutting the nasal stump with a knife. The physician should then place the skin on the nose and stitch the two parts swiftly.

Sushruta edified the bases of



modern surgery and demarcated eight types of procedures utilised in surgery, thereby effectively laying the foundation for further evolution of life-saving medical research.

The first cataract surgery is also said to have been performed by Sushruta himself. In order to remove the cataract from the eyes, he used a curved needle, *Jabamukhi Salaka*, to loosen the lens and push the cataract out of the field of vision. The eye would then be bandaged for a few days till it healed completely.

In an era which lacked sedatives and pacifying anaesthesia, the patient would unfortunately be tied up, in order to ensure minimal movement. Often psychological, rather than physiological techniques were used to pacify the patient. The patient would be eased into a fatigued, often fugue state, with the aid of opium. Wine was often used as a numbing agent, thereby being the precursor of modern anaesthesia. Natural

antiseptic substances which contain lysozymes such as milk or saliva were often used to moisten the area under scrutiny. Ingenious techniques were employed which involved use of leeches to get rid of blood clots in wounds.

Sushruta's surgical works were later translated into Arabic and through the Arabs, his works were introduced to the West. History confirms no other source that explains the origins of such thinking and procedure, thereby signifying that India, through its historical surgical advancements, provided the world with revolutionary and innovative breakthroughs.

The historical development of us, as people, and that of life science itself remains simultaneous and parallel, inseparable in essence, with one supplementing the other.

BITERRORISM

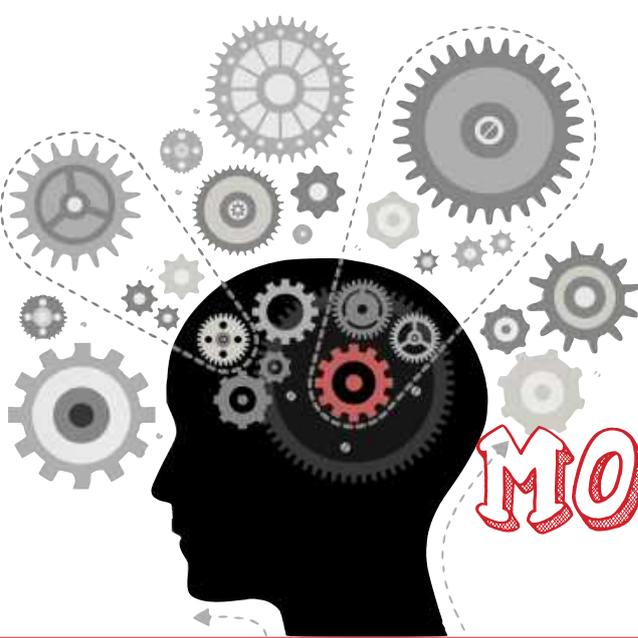
Asmita Dubey, SYBSc Life Sciences

The conventional image we draw in our minds when we hear warfare and terrorism is that of guns blazing, bombs detonating and millions of lives being lost. Rarely do we think about those tiny microbes that are being used as a lethal weapon. This weapon of mass destruction has been used since 600 B.C, when arrow heads were dipped in manure and inserted into corpses to kill by infection. This weapon that is often referred to as the poor man's hydrogen bomb has been used by a number of factions for varied purposes.

During the World Wars, countries raced to procure potential deadly bioweapons. Hefty investments were made for weaponisation of biological agents like anthrax and small pox. Later the focus shifted to viruses due to their

potency. British soldiers gave tribes blankets which were sown with smallpox. In World War I, Germans infected horses of their enemies with glanders and in World War II, the Japanese army dropped plaque infected fleas on Chinese cities leading to the death of thousands.

Even though it has been widely condemned, large number of countries clandestinely continue research in biological warfare. With the developments in the field of biotechnology, biochemistry and genetic engineering the threat is greater than ever. The threat of Bioterrorism is real and worthy of attention and we need to develop constructive measures to fight it.



ARE YOU BEING MONEYPULATED?

Jigyasa Dayal, SYBSc Life Science

With the advancements in technology and the extensive outreach of the media, marketing has become more prevalent than ever before. Not only are these advertisements cleverly worded with rhymes, catchy jingles and amazing discounts, but also there is a reasonable amount of psychology and biology at play, which often go unnoticed. Several studies in biopsychology have revealed that our brain works on quite predictable rhythms and is prone to certain cognitive biases. A cognitive bias is a processing error by our brain, which is often responsible for our illogical acts and decisions. These are shortcuts that our brain takes to process information faster but not always accurately. Once this became common knowledge, the corporate world left no stone unturned to utilise it and consequently neuromarketing, that combines the fields of biopsychology and marketing, was born.

Some common cognitive biases that we can easily observe include the 'Confirmation Bias', wherein we tend to believe in only those arguments that favour our set of opinions. Another is the 'Bandwagon Effect', whereby we tend to side with the more popular opinion while leaving personal opinions unexpressed. The 'Ostrich Effect'

Rosemary Babu, FYBSc Life Science

makes us deal with a situation by hiding or denying it (we all do this during exams, don't we?). These biases are very common and experienced in day to day life. However, for effective marketing strategies further subtle and specific biases often come into play.

Biases like 'priming' takes advantage of the associative capability of our brain. Priming can be seen in how different brands have arrested certain colours, shapes or fragrances in our minds as their own. If we think of a combination of bright red and yellow, we are reminded of McDonalds. Be it the unforgettable jingle of 'MDH Masala' or the iconic washing powder 'Nirma', these advertisements bring back childhood memories. Hence our minds become 'driven' to buy these products simply because we associate them with a distinct memory.

Another interesting strategy is the use of 'method of reciprocity'. This idea is derived from the concept that if you are given a good discount or offer, you will want to reciprocate the goodwill in some manner. This helps in gaining customer loyalty and imposes the need on you to buy something on the grounds of 'politeness' in order to return the favour. Though unfair, it is extremely effective since it pricks the ethical and social morale of a person.

DID YOU KNOW?

In the 1900s, heroin was marketed as a cough medicine for children.

Suppose the costs of a small, medium and large packet of popcorn are Rs. 25, Rs. 32 and Rs. 40 respectively. You require a medium packet but since five more rupees will fetch you a large one, it seems perfectly reasonable to go with the latter option. If the medium option was removed, the difference between the other two is appreciable enough for you to stick to buying the smaller packet. The 'decoy effect' comes to play here. The middle option often gives a frame of reference or a 'bridge' that will make you want to opt for the costlier option.

Have you ever just been introduced to a product and then seen it pop up everywhere else you go? This again is due to the 'Baader- Meinhof phenomenon'. It is because your brain subconsciously keeps an eye out for it and then every time you see it, reassures you that the product has always been there and you were just too oblivious of its existence. This explains the purpose of billboards and advertisements. They stealthily drop the slightest hint of the product and let your mind do the rest of the work.

However, as research is done on the efficacy of these techniques, an ethical question is being raised: has the customer actually been given complete free will or perhaps just a delusion of it?

Now a question that arises is why does our brain have this tendency of taking shortcuts and making such biased, illogical decisions? Scientists have theorized that these biases or glitches actually serve as an evolutionary adaptation. If you are walking on a lonely street, you are easily scared by a harmless shadow. During prehistoric times this

shadow could have possibly been a sabre-toothed tiger. Hence, the heightened response without complete information could actually save the early man's life.

Although our brain is capable of carrying out 10^{16} processes per second, our brain simply cannot process the overwhelming amount of information it receives every second. Hence it tends to 'omit' certain details so as to react to situations quicker. Thus, these biases reduce the workload on the brain.

Cognitive biases can have far-reaching consequences. For instance, 'apophenia' is a type of bias that makes us see a meaningful pattern in random, unrelated data. This is observed in scientists who have certain hypothesis in mind before starting their research. They tend to believe in the data that supports their hypothesis even though there might be convincing data against it.

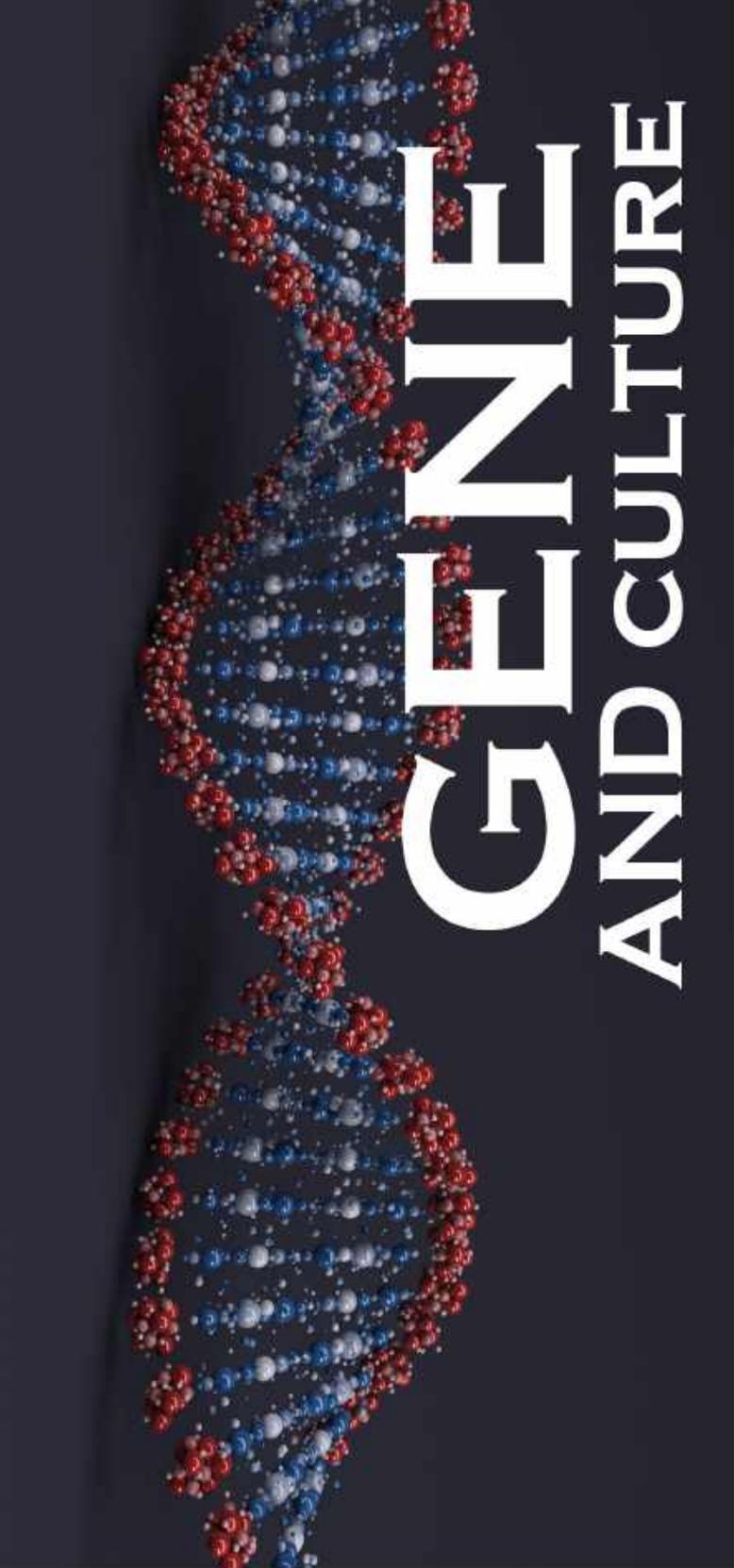
Cognitive biases evolved because sometimes an immediate response was more important than to consider all variables and come up with a more accurate but slower solution. In the modern age when the threat of the wild no longer plagues us, these biases have been instrumental in expanding and innovating the field of marketing in ways that need almost little to no capital. Globalization and urbanization of many developing countries owe their foundation to such marketing strategies. In a metropolitan scenario, they are inevitably unavoidable. They have been pre-programmed into us and we cannot always avoid them but we can surely recognise these biases at play in our daily lives.

DID YOU KNOW?

If human eyes were digi-cams, they would comprise of 576 megapixels. Our eyes can identify 10 million colours and nose can remember 50,000 scents.

Bidding
to one of the most
who has touched the lives
kindled a flame of
which shall continue to

*adieu
vibrant personalities
of several students and
passion in them
burn for years to come.*



GENE AND CULTURE

CHALKING OUT A JOURNEY TOGETHER

Bhuvan Majmudar, FYBA Sociology

You shouldn't be able to drink milk, or eat that cheese burst pizza without complaining of severe stomachache and multiple trips to the washroom. Our ancestors could not drink milk or consume and digest any milk products. Humans, as we all know, are the only beings who regularly consume other mammals' milk to nourish themselves. Don't you think it is a bit odd? It was only around 9,000 years ago that humans developed a digestive system efficient enough to breakdown and metabolize lactose – a sugar found in milk and milk products. Until then, the entire human race was, quite simply, 'lactose intolerant'. So what do you think was the cause for this change? What made our human digestive system suddenly accept non-human milk? This is where 'culture' comes into the picture.

Culture is a very complex idea, defined in the words of anthropologist E. B. Tylor as "that complex whole which includes knowledge, belief, art, morals, law, custom and any other capabilities and habits acquired by man as a member of society." Culture forms a fundamental basis to the development of human beings, and this article will illustrate and analyze the link between culture and evolution. Let us begin with the analysis of the aforementioned evolutionary process of adapting to the consumption of non-human milk.

Prior to 4,000 BCE, most humans did not produce a protein that allowed them to digest lactose after being weaned. With the dawn of civilization, tremendous changes ensued. Humans began the domestication of animals, practicing agriculture and most importantly – dairy farming. After Europeans began to drink the milk of domesticated animals, the genetic adaptation favoring lactose consumption spread through the continent. This proves to be a classic example of how cultural shifts can lead to changes in behavior that affect biology. Interestingly enough, it turns out that cultures with a history of dairy farming and milk drinking have a much higher frequency of lactose tolerance – and its associated gene – than those who don't.

Culture and Genetics were earlier considered to be mutually exclusive processes, but in recent times, their impact on each other is being realized and their interactive patterns are being analyzed. Recent studies show that these two phenomena are intimately connected and scientists are calling it the '*gene-culture co-evolution*'.

Another example of gene-culture co-evolution can be seen in the Polynesian community. Polynesians have a high prevalence of Type II Diabetes. Anthropologists and scientists now trace this high prevalence rate to the 'culture of exploration' that existed in early Polynesians. As they settled in the islands of the Pacific Ocean, they had to go through long voyages in the oceans, suffering severe cold climatic conditions and frequent starvation. As this was detrimental to their survival, they developed what is called a 'thrifty metabolism'. Such a metabolism ensures that people build up and store fat deposits quicker when food is readily available so as to avoid, or at the least prolong deaths due to starvation. Due to natural selection, this genetic component of having a thrifty metabolism was recurrently observed amongst the Polynesian descendants. This very gene, which helped early Polynesians survive in tough climates, has now become a cause of serious health concerns among the

modern Polynesians who face no such shortage of food and receive constant nutrition. They developed a susceptibility to Type II Diabetes not due to their own sedentary lifestyle but due to the fact that their ancestors voyaged across oceans and developed a metabolism which would keep them from dying of hunger only to have passed it on to people who no longer need it. This can be seen as one of the negative manifestations of gene culture co-evolution.

If we look for cases where evolution and genetics have been influenced by the way of life of humans, we can find numerous examples. One such example can be observed in the most nascent stage of human evolution, the Upper Paleolithic Age. By the dawn of *Homo erectus*, humans had discovered fire. Initially the early humans feared fire, but slowly as they realized its effectiveness, they domesticated fire. Fire was used to not only drive predators away, but also roast food (majorly meat products), which were until then eaten raw. Roasting the meat through the cooking of food assumed the roles of softening the food, breaking down of tough meat that used to previously be done by large teeth and heavy jaws of the *Homo*



erectus. Natural selection favored the role of fire and this led to major changes in the physical structure of humans. Large bones and muscles for chewing grew smaller in size. Hence, as a result, the Upper Paleolithic human developed smaller jaws with smaller teeth. The digestive enzymes that would usually help in breakdown of raw meat were no longer needed and were thus eliminated from the biological system. It also affected the functioning of the organs such as the stomach and the intestines, which would no longer have to perform rigorous breakdown functions. Due to all of these developments, and others, the physical stature and biological systems of hu-

mans changed over time from the *Homo erectus* to the *Homo sapiens* and to the modern human being. The bulky body-frame grew leaner; the ability to digest uncooked meat was lost; manual dexterity increased; the ability to survive in extreme weather conditions was gained due to the development of the brain which helped manipulate natural objects for personal gain; all of this was caused due to the changes in the way of life of humans and their knack of adaptability. Hence, the Upper Paleolithic age characterized fundamental changes in the evolutionary process of humans due to the internalization of rudimentary cultural traditions.

Speaking of the universal 'double standard' of sexual behavior sex researcher Alfred Kinsley says, "Among all people everywhere in the world, the male is more likely than the female to desire sex with a variety of partners." But why is this so? Biologically speaking, the importance of a single egg and a single sperm is very different. For a healthy male, sperm represents a 'renewable reproductive resource' since the testes keep producing sperms through most of the life course. Every ejaculation of a male contains hundreds of millions of sperms. However females on the other hand, are born with a limited reproductive resource. A newborn female's ovaries contain her entire lifetime allotment of follicles or immature eggs. To add to this limit, women generally release a single egg cell from their ovaries each month adding to the

follicle deficit (in comparison to men). Due to this difference, men reproduce their genes most efficiently by being promiscuous, while women to be efficient must carefully select a mate whose qualities will contribute to the child's survival. Here, we see a stark biological difference influencing the behavior of people in the global context..

By now, it is fairly illustrated that evolution and cultural practices are inter-dependent to a large extent. While looking at instances through the eyes of an anthropologist, do we see a cultural sway over biological facts. Thus anthropology is often called – "The most humane of all sciences and the most scientific of all humanities". The core of this subject is to establish a relationship between scientific human development and its social aspects. To realize that our lifestyle could cause vital evolutionary changes in future generations should be reason enough to start anew. Will we be able to ever find out whether our current lifestyle plays a key-role in the evolution of our species many generations later? What aspects of our popular culture will affect biology? We have smart phones, smart televisions, smart refrigerators, smart water heaters and smart homes. What will be the result of the overuse of electronic gadgets? Will our succeeding generations have physical deformities? Or will they become immune to the radiation from electronic appliances? In all probability, we will never find out... Maybe, it is not for us to find out, after all.

DID YOU KNOW?

Apples are 25% air. They actually float on water.

90% of the food human eat, comes from just 30 plants.

85% of plant life is found in the oceans

Bananas contain tryptophan, an amino acid that the body converts to serotonin. This serotonin makes people feel happy. Thus, bananas can be called the 'happy fruit'!

PSYCHOLOGY AND THE COMMON COLD

Vidya Venkatesh, SYBA Psychology

Noses covered with tissue paper, sneezes resounding in corridors and loud coughs during lectures are not uncommon, particularly during the cooler months of the year. These are all symptoms of common cold, caused by viruses of different kinds. Stress and negative emotions lead to reduced immunity, thus increasing one's chances of catching a cold.

Psychoneuroimmunology (PNI) is the field of study that looks at the relationship between emotions and other psychological aspects and the human immune system. It puts forth the idea that the mind is inseparable from the body. Hence, any biological condition that can be understood by taking into account the psychological state of the person. For example, one often observes that during exams, one is more likely to cough, sneeze and feel weak.. These are all stress related symptoms of common cold . Stress results in increased levels of the hormone cortisol, which is known for eliciting the flight-or-fight response in complicated situations. This hormone creates imbalance in insulin and epinephrine generation. Until the problem at hand is solved, cortisol remains high. Cortisol



reduces the inflammatory response ability of the body, which is required to fight the virus and prevent infection. Hence, when the virus attacks the body that is in stress, there is a higher chance of an infection to the body.

Research shows that one's susceptibility to cold is greater in an actual stressful event as compared to a perceived stressful event. . Another study shows that antigen levels in one's body are higher on days when the person is in a positive mood. This proves that a positive state of mind may prevent infection from setting in, since antigens determine the strength of the body's immune response. It is said that a healthy mind resides in a healthy body. The reverse is also true. The next time you catch a cold, take a moment and review your state of mind. Are psychological factors overpowering the biological aspects? If so, it is time take things in your hand and work on your system: your immunity and your mind.

DID YOU KNOW?
When we sneeze, our bodies get rid of infected cells. The average sneeze spreads over 10,000 viruses, up to 30 feet.

MAD GENIUS: THE STEREOTYPE UNRAVELLED

Joshuah Fialho, SYBSc Life Science

Tarun Iype, SYBSc Life Science

The link between mental illness and creativity is just as shrouded in controversy today as it was centuries ago.

What makes testing a correlation of this kind extremely challenging is determining whether creativity, a parameter which itself is ambiguous and difficult to estimate quantitatively, is genetically acquired or a by-product of one's upbringing. Moreover, the definition of mental illness is often not agreed upon unanimously.

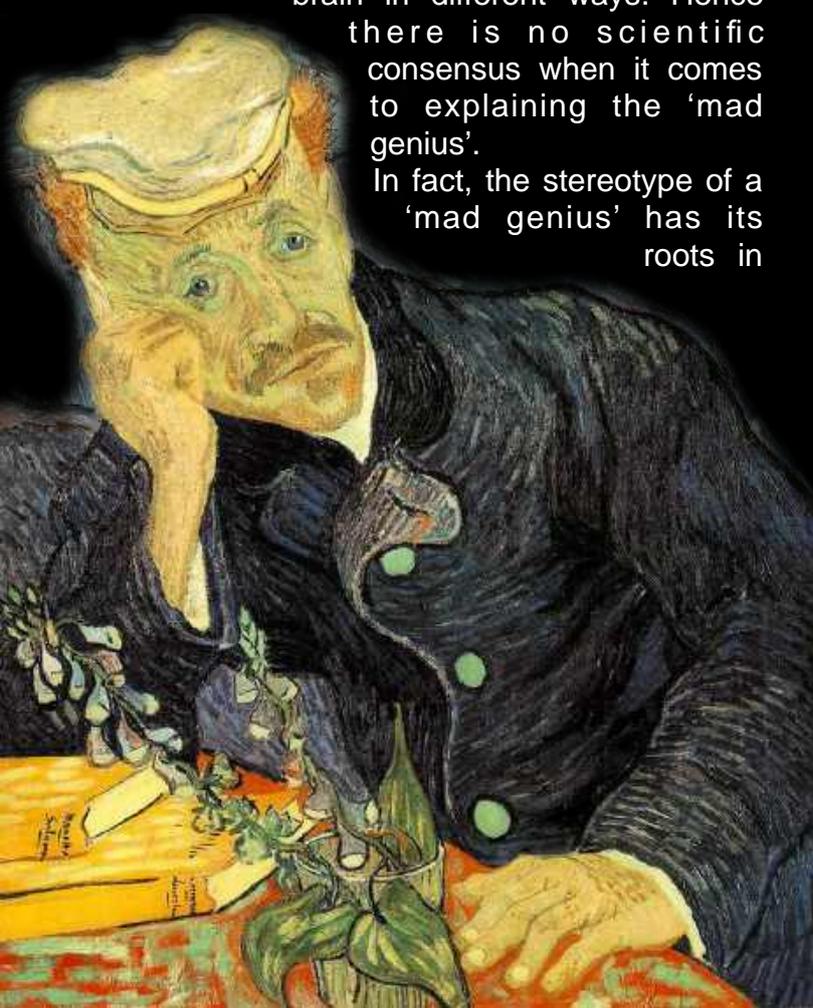
From a neuroscience perspective there are different types of creativity: one kind involves creation of an artistic painting or improvisation of a piece of music while the other may deal with lateral thinking and problem solving. Moreover, the term 'mental illness' covers a wide spectrum of diseases, which affect the brain in different ways. Hence there is no scientific consensus when it comes to explaining the 'mad genius'.

In fact, the stereotype of a 'mad genius' has its roots in

ancient Greece. Believe it or not, artists even feigned eccentricity to get people to believe in their so-called genius. However we also have many modern examples like Vincent Van Gogh, T.S Elliot and Georgia O'Keefe vindicating this stereotype.

But studies show various links between creativity and mental illness. For example, a study performed on 1.2 million Swedish people showed that people in artistic or scientific jobs did not have a higher prevalence of diagnosed mental health problems but the direct relatives of those diagnosed with mental health problems such as autism, schizophrenia or bipolar disorder had a high presence in creatively demanding jobs. This strange relation was explained by the expression of certain personality traits that were present in this specific demographic that enhanced their ability to do creative tasks. When asked to perform a task, people with these personality traits showed an inability to suppress the activation of the 'precuneus', a part of the parietal lobe that is linked to self-consciousness and the retrieval of memories. This phenomenon seems to show that being creative involves a less controlled retrieval of memories and hence, contributing to associations which help in creative tasks. Along with this, a reduced latent inhibition (mechanism involved in gauging the importance of a stimulus) somehow contributes to an enhanced ability to perform creatively demanding tasks.

Recent studies also show that both schizophrenia and creative thinking demonstrates unusual frontal lobe activity. To be more precise, people with high creativity as well as schizophrenics have a lower density of dopamine receptors in their thalamus. Thus the brain "takes it slow" and is able to form conclusions or ideas that are considered off the wall.

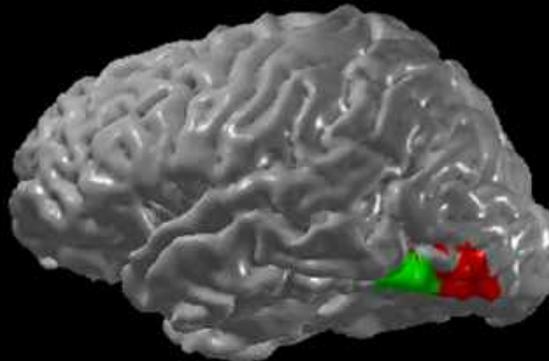


Hence the similarity between creativity and mental illness goes deeper than sharing the same brain region, highlighting the resemblance in activity of neurotransmitters.

Another common notion is that creative people experience synaesthesia. Interestingly, people suffering from bipolar disorder and schizophrenia have increased synaesthesia - a condition where stimulation of one sense leads to the experience of another, as a symptom of their illness. Synaesthetes can 'see sounds' or 'hear colours'. A heightened emotional response to colours or sound results in better expression of emotion through art or music. Mental disorders such as bipolar disorders, schizophrenia, depressive disorder, narcissistic personality disorder, have featured in diagnosis for eminent personalities such as Sylvia Plath, Leo Tolstoy and Ernst Hemmingway.

Another disorder which is frequently linked to creativity is 'Autism Spectrum Disorder', commonly known as Autism. It is a brain based developmental disorder that affects the nervous system, thus impairing ability to communicate and interact. Two main characteristics of the mental reasoning processes in autistic persons are: Seeing ordinary things in a different light and thinking out of the box. Surprisingly they are not quite the same!

If someone asked you to find different ways to use a paper clip, common answers would be a pin, something to reach into tiny spaces or



The synaesthetian brain -
source: Wikimedia Commons

maybe a hook. The more novel answers would include, holding cut flowers or as a token in a game. In a divergent thinking test like this, people with autistic traits will have very few answers but they will be unique. Hence they exemplify the process of "taking things slowly" thus being able to filter out and come up with ideas that seem out of the box.

Research in this field upholds the theory that genetics might play an important role in the creativity-mental disorder link. An article published by Association for Psychological Science establishes a link between creativity and 'neuregulin 1' which is a gene related to psychosis. Thus common genes associated with creativity are also associated with increased susceptibility to mental illness.

Hence under intense scrutiny from the scientific community the stereotype of "mad genius" is slowly unraveling. It is yet to be determined whether there is a clear link between creativity and psychological disorders. If it exists, does such a similarity stem from a similitude in nature or nurture? The threat looms large that by institutionalizing people, a potential genius could be lost. The sooner we understand that it is a difference and not a deficit that separates us from persons suffering from mental illness, there is a greater chance of us obtaining the insight into the complex relationship between mental disorder and creativity.

DID YOU KNOW?

The brain itself cannot feel pain. This is why brain surgeries are performed without anaesthetics, with the people still conscious.



SCIENCE SUPPORTS TRUMP

Ashmita Chatterjee : TYBSC Life science

In 2016, the people of the world came together with a common interest in the outcome of the American Presidential election. Whether one was American or not, everyone had picked sides; you were either a Trump supporter, a Clinton supporter or a temporary Sanders supporter (sorry!). With the elections came a slew of scandalous, sometimes downright immoral comments about both candidates (but mostly Trump). Leaked videos, rumours and reports were soon to join the party. As a witness of this political debacle unfolding in another country, I, among others, questioned the intelligence of Trump and all his supporters across the world. How could millions defend an individual who was labelled as “a serial liar, rampant xenophobe, racist, misogynist, a birther and one who regularly incites political violence?” Surely people could see the flaws in all his plans!

Political beliefs have been studied by behavioural scientists and experts for decades. While most of us may believe that our political stance stems from our brain’s ability to distinguish right from wrong, scientists believe that they are actually predetermined at birth. Genopolitics or the genetic basis for political participation, is a field of Genetics that claims to attribute our predilections towards certain candidates and their ideals to heritable changes.

The foundation of Genopolitics was an essay published in the American Political Review in May 2005, authored by John K. Alford, Carolyn Funk, and John R. Hibbing titled “Are Political Orientations Genetically Transmitted?”. According to this essay, Americans can be divided into Liberals and Conservatives based on their answers to a survey. The survey involved instantly answering, in only yes and no, to varied questions on matters ranging from abortion, immigration, homosexuality to X-rated print media and nuclear power. The result of the survey unveiled a deep rooted, transcultural difference that dates back several centuries.

The authors identified a fundamental difference between the Conservationists and Liberals and labelled this as the “Absolutist” versus “Contextualist” orientation. Conservationists showed the Absolutist way of thinking, characterised by preference towards in-group unity and suspiciousness towards out-groups which is antagonised by the Contextualist orientation of the Liberals. The proponents of Genopolitics strongly believe that this difference pervades human history. The authors also argued that the primeval mind-sets remained conserved throughout the years since both Contextualists and Absolutists seek mates that share the relevant genes that lend the same political outlook. This technique of “assortative mating” has led to the manifestation

of these orientations as Liberals and Conservationists. In fact, it has been stated that the effect of the genes can be diluted if there were to be an instance of cross mating between the two groups, which implies that they function like heritable traits.

Are these claims authentic or is it a way to explain away beliefs that cannot be considered remotely moral? The validity of Genopolitics is based on a rather shaky foundation. The findings of these genetic studies are largely based on twin studies, which involve analysing a particular trait between identical and fraternal twins. If the attitude or orientation is shown to have a greater degree of similarity between identical as compared to fraternal twins, then this similarity can be explained on the basis of genetic principles. The approach that is commonly used in such studies, is the exposure of both types of twins to similar environments. The similarity could, however, be a result of higher similarity between experiences, education and upbringing that the identical twins may have received as compared to those experienced by fraternal twins. Hence, the consistency could be due to a similarity in environment rather than genetic composition.

All these studies might have had their flaws and unanswered questions, but we now know one thing without a doubt - there is definitely a strong link between genetics and political behaviour. Now, the question that had to be answered was - which genes?

Naturally, the first place to start looking for such genes would be among those that are already known to account for variations in social behaviour. And so these were narrowed down to two probable candidates - the MAOA and 5HTT genes. These two genes have a strong effect on the serotonin system in parts of the brain that regulate fear, trust and social interaction. Serotonin is a neurotransmitter that, among other functions in the body, has a strong influence on social behaviour. In fact, results of studies indicate that people with less active variants of these genes have a greater tendency towards antisocial behaviour. And so one of the ways in which genes influence voter turnout and political participation is by increasing a tendency towards prosocial

behaviour.

Well now we understand how our genetic makeup influences our tendency to participate in political activities. But what about political orientation? How can this be influenced by genes? Once again, the answer lies in a chemical of vital importance in our body - dopamine - and here's how. Dopamine is a neurotransmitter that plays a crucial role in reward-motivated behaviour and is associated with pleasure, movement and attention. The DRD4 or Dopamine D4 Receptor gene is often referred to as the 'adventurous' gene, since it is associated with risk-taking behaviours. All of us have this gene, but according to a recent study at the National University of Singapore, less than 50% of the study subjects had a variant of this gene, called the 4R variant. And this is the interesting part - women with this particular variant showed a predisposition to low-risk attitudes and hence, political conservatism.



So would that mean that you could as easily be a Trump supporter as a Clinton supporter due to the genes you inherit? Although the claims of Genopolitics are critiqued by social scientists and geneticists alike, experts do concede that political beliefs result from a combined effect of one's genes and social environment, however the effect of one factor can outweigh the other. Does this then justify the hateful attitude of Trump and his supporters towards Muslims, women, homosexuals and immigrants? Hell no!

DID YOU KNOW?

Zombies do exist! *Leucochloridium paradoxum* is a parasitic flatworm that controls the mind of its snail host, forcing it to travel to open spaces in order to be eaten by a bird, so that the parasite may complete its life cycle.



INSECTIVOROUS PLANTS

Aditya Sane, FYBSc Physics

‘Carnivorous plants’ sound like an oxymoron, right? Interestingly, it isn’t. Carnivorous plants are plants that grow in nutrient deficient soils. In order to meet their nitrogen requirements they usually have their leaves modified into traps which they use to capture arthropods and protozoans. Quite like the human stomach, they use acids to digest the insect.

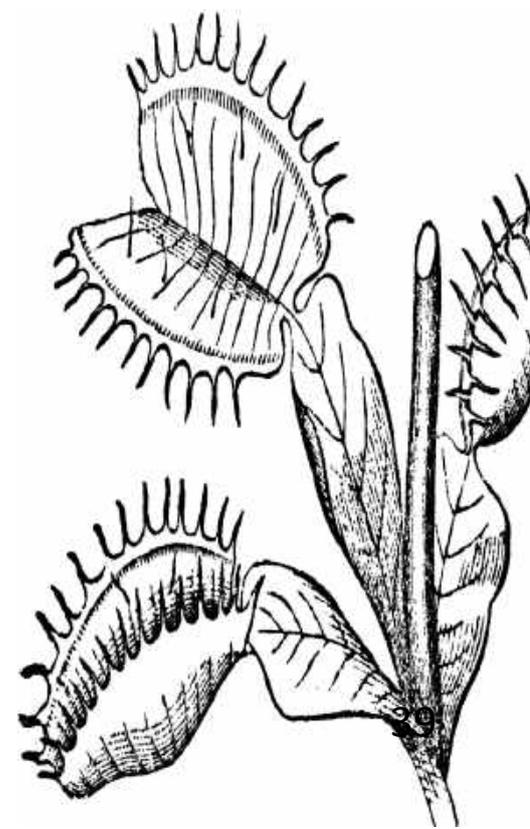
How do these plants trap their prey? After all, plants are rooted and immobile whereas insects and animals are capable of movement to avoid their predator. In order to trap insects, plants need to be fast, if not faster. Plant movements are broadly classified into tropic movements and nastic movements. Tropic movements are direction based and very slow (noticeable over the course of hours or days). In contrast, nastic movements are fast, reversible, orientation-based movements based on direction independent stimuli. These nastic movements, unlike majority of the plant movements, happen in very short timescales, despite the lack of muscles and nerves. Carnivorous plants use such mechanisms to trap and gain advantage over their preys.

The biomechanics of trapping mechanisms are quite complex and have intrigued scientists around the world. In a few of the insectivorous plants such as the Venus Fly Trap (*Dionaea muscipula*) and Bladderworts (*Utricularia stellaris*) these have been studied quite extensively and are discussed below.

Venus Fly Trap (*Dionaea muscipula*)

Darwin, after studying the Venus Fly Trap, called it a “Wonder of Nature”. The most wonderful feature of the Venus Fly Trap is its ‘open mouth’ which resembles a bear trap and snaps shut to capture its prey. The modified leaves of the Venus Fly Trap have two parts, the upper and the lower leaf. The lower leaf, called ‘petiolus’, has an expanded leaf-like structure. The upper leaf has three main features: a shell like ‘open mouth’ with two symmetrical lobes, 3 to 5 mechano-sensitive hair on the inner side of each lobe (that generate electrical impulse when touched) and cilia bordering the lobes which form the many interlocking ‘teeth’ that prevent the captured prey from escaping.

When the same or two different mechano-sensitive hairs are triggered within a gap of at most 20 seconds, the trap snaps, enclosing the prey. As the arthropod prey struggles within the trap, more and more sensitive hairs are triggered and the trap closes tighter.



The cilia on the two lobes interlock preventing the escape of the prey. Triggering of sensitive hair in quick succession is a necessity as this tells the plant that it has captured prey and not some non-prey (seed or stone). This prevents it from wasting energy.

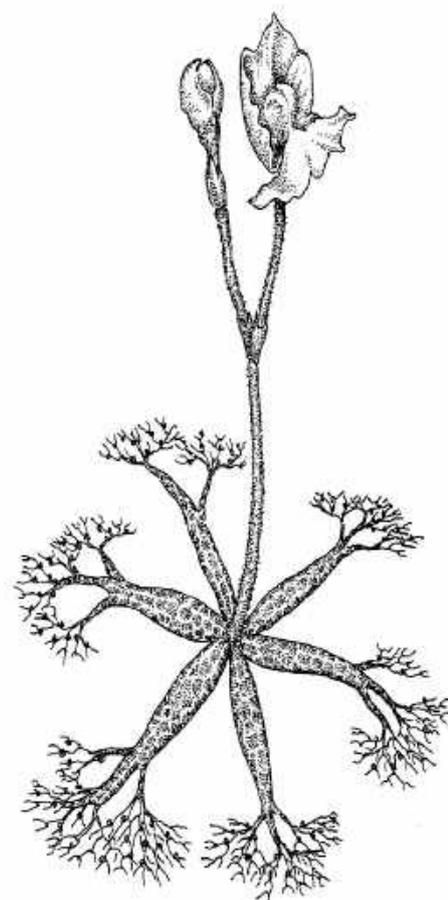
Once the hairs are triggered the trap closes in a few tenths of a second. This time is too short for the movement to be explained only by movement of water across the cell walls of the lobes. The mechanism that amplifies the speed of closure relies on snap-buckling instability, analogous to the buckling of an elastic shell. This means that, there are two stable states of the Venus Fly Trap - the open state and the closed state. The two lobes of the trap are curved outward from the midrib in the open state but are curved inward in the closed state. Once triggered, the lobes use energy to change their 'open state' curvature in the direction perpendicular to the midrib, i.e. the lobes try to bend inwards. However, the shell-like structure of the lobes proves to be a geometrical constraint. This active bending causes the trap to gain elastic energy till the stored elastic energy becomes so large that each lobe buckles inside out, shutting the trap. To understand this better, imagine a tennis ball that is cut in half. If we start pressing the bulging, convex side of the ball towards the centre, there comes a time, after enough force has been applied, when it suddenly pops to the other side and the curvature of the half cut ball changes. This is analogous to when the trap closes.

Once the trap is closed, it takes approximately 20 days for the plant to digest the prey. After digestion, the trap reopens and the exoskeleton of the insect is carried away by wind or water. Each trap can close up to a maximum of 5 times irrespective of whether it catches a prey or not. Thereafter, the leaf withers and a new leaf takes its place.

Bladderwort (*Utricularia stellaris*)

These are free floating rootless aquatic plants and have evolved a carnivorous life style to supplement their nitrogen intake. The trap consists of a modified leaf in the shape of a bladder (up to 10 mm in size) which is equipped with a trapdoor. To set the trap, the plant actively pumps out water from its bladder sucking the elastic walls under the influence of a negative pressure of -16 kPa. The trapdoor is a shallow dome whose convex walls face outward when the trap is set for capture. When a prey stimulates the trigger hairs located at the base of the trapdoor, the trap door suddenly opens inwards and the negative pressure forces the water, along with the prey, inside. The triggering again forces a change in the open state curvature. The convex curvature reverses to concave curvature. In this new state, the trapdoor is no longer able to resist the pressure difference. The entire process from triggering to closing of the trapdoor happens in a window of about 10-15 milliseconds and represents, by far, the fastest movements recorded in carnivorous plants.

Carnivorous plants use complex mechanisms relying on rapid nastic movements to trap insects. Only once we begin to understand how they work can we truly appreciate their complexity and magnificence. These plants would serve as great models for tactile devices of the future.



POLYMER BASED NANOCARRIERS: A NEW FRONTIER IN DRUG DELIVERY SYSTEMS

Aditya Munir Chalisehar, TYBSc Chemistry

The field of medicine has advanced in leaps and bounds in the past century, with breakthroughs seen in the flexibility of designing a specific drug. Various methods have been designed, in order to deliver the drug to a particular site in the body, for precisely targeted action.

The importance of a well-designed drug delivery system stems from the fact that the therapeutic efficacy of drugs is limited by their bioavailability, solubility, stability and safety. 'Bioavailability' is the small fraction of administered drug that reaches the target cells for therapeutic action.

In this ever widening scenario of drug delivery design, "nano" carriers have hailed a new era. In a nutshell, a nanosystem is one where the particles have colloidal sizes, in the range of 1 – 1000 nm. A wide variety of drug loaded nanocarriers composed of various materials have been developed utilizing both organic and inorganic materials. This is a noteworthy achievement since it has given rise to systems with targeted applications.

In the present discussion, we will limit ourselves to polymeric nanocarriers. The emphasis on polymers stems from the fact that they are extremely versatile compounds whose generation is specific to our needs. They are used in the form of tablets and capsules and the drug can be covalently linked to the polymer which is designed to target specific active cells. These can easily be used for nanoformulation to design systems with features such as long circulation

times, local drug delivery, controlled release, degradability. Multi-block polymers, dendrimers, biodegradable and stimuli responsive systems are among the drug delivery systems that have been developed because of the extraordinary tunability of the molecules.

The functionality and targeting of the system can be revamped before or after the formation of the nanocarrier. The method of preparation depends mostly on the nature of the reactants or monomeric blocks being used for polymerization. Usually a self-assembly process is utilized for the polymer to be generated. Extensive research in these fields have generated highly flexible and designable systems in which the size, surface charge, drug loading and release mechanism is easily adjusted.

These methods may involve one of the following:

[i] Emulsion Solvent Evaporation Process:
In this process, the polymer is taken in a volatile organic solvent, which is immiscible in water. Manual processes such as ultra-sonication generate an emulsion, and the evaporation of the volatile solvent generates the product nanocarriers.

[ii] Nanoprecipitation involves dropwise addition of a polymer in a volatile solvent into the aqueous phase, which diffuses in the medium. Subsequent evaporation of the solvent yields the nanocarriers.

Polymeric Nanoparticles

These are solid colloidal particles ranging in size from 10 – 1000 nm. Their nanocarrier activity can be seen by loading the drug on to it by methods such as entrapping target drug within nanoparticle capsule or matrix, attachment or adsorption of the drug on the polymer matrix or dissolution of the drug in nanoparticle matrix.

The advantages of polymeric nanoparticles include their ability to stabilize volatile moieties present in the drug and hence increase the lifespan of the drug. Other advantages include the ease of synthesis, increased bioavailability and tunability of the particle along with increased specificity that can be obtained by impregnating the matrix with antibodies and making them stimuli sensitive.

Polymerosomes

Polymerosomes are artificial vesicles, which are hollow spheres. Due to the cavity present within them, they can enclose solutions to act as reservoirs and release the drug under specific conditions. These can easily protect a sensitive molecule present in their core region. Since, these can be designed to allow selective permeability of certain molecules, they are also called 'synthosomes'.

These are characterized by a corona which is hydrophilic and a hydrophobic bilayer membrane.

We may tune the properties of the polymerosomes with respect to drug delivery and action, by impregnating the vesicle with antibodies, which cause dissolution of the bilayer upon interacting with specific markers. We can also make these molecules sensitive to the pH of the site of action, facilitating sustained release under specific pH conditions.

These are usually prepared by two types of methods:

- [1] Solvent Switch or Phase Inversion
- [2] Polymer rehydration

Their existing morphologies involve spherical and cylindrical vesicles or micelles. Their morphology depends on the interaction between the

hydrophobic parts and the % volume of the hydrophilic part:

- [1] 10-40%: Vesicle
- [2] 40-55%: Cylindrical Micelle
- [3] 55-70% Spherical Micelles

This can be tuned to make degradable and non-degradable depending on block constituents.

The major drawback encountered is the difficulty to perform an efficient scale-up of the nanocarrier formulation while maintaining all the parameters for efficient drug release such as nanocapsule size, selective degradability, targeted release, concentrations of active substance

Applications of nanocarriers

The tunability of these carriers makes a spectrum of possibilities available for the use of these carriers.

Mentioned below are several case studies which have been proved through mice model studies and have shown greater efficiency with lesser toxicity.

1. Using folic acid targeted nanocarriers for cancer treatment.
2. Biotin functionalized targeted nanocarriers for cancer treatment.
3. Peptide functionalized and targeted nanosystems for cancer treatment.
4. CNS delivery of nanocarriers for brain cancers.
5. Treatment of
 - Rheumatoid Arthritis, Managing HIV, Managing Pain and Depression, Managing brain ischemia, Vaccination delivery, Diabetes: Insulin delivery, Targeting injured tissues.

Currently the focus is to develop robust and reproducible preparation protocols which can be used in multiple animal species and thus translate to clinical trials on humans.

RIPPED GENES

Arjun Ashoka, SYBSc Physics

Ever since its humble beginnings in Mendel's pea plants, genetics has taken the world by a storm. The massive repercussions of genetics in the scientific world are so far reaching that it even resonated with Hollywood in the X-Men series. Despite the inconsistencies of science in the X-Men series, one of the characters, Hank McCoy a.k.a. "Beast", does capture a glimpse of real world gene therapy with his mutant 'suppression serum' which suppresses a mutated gene. Gene therapy is the one branch of applied genetics that still holds the same sensational power as represented in sci-fi movies.

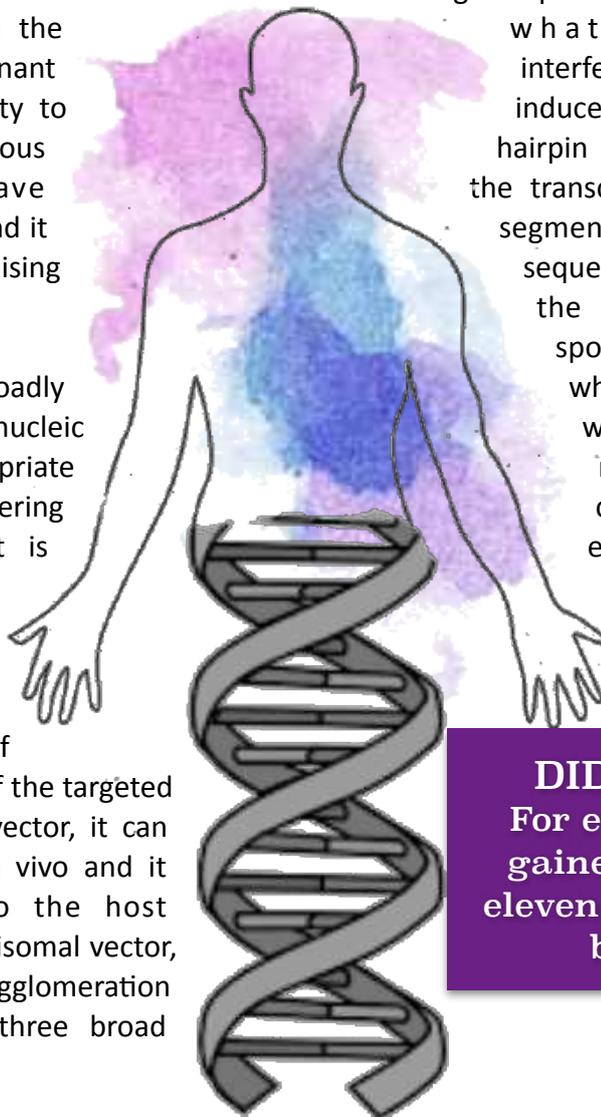
The idea of gene based therapeutics has been around for a while now, with the first clinical trials carried out in the 1980s. However, in the two decades of research carried out since, several obstacles have curtailed enthusiasm in the field. Recent developments in the 21st century such as recombinant DNA technology and the ability to transfer and express exogenous genes in foreign cells have reignited interest in the field and it is now emerging as a promising discipline.

Gene based therapeutics is broadly defined as the introduction of nucleic acids into cells, using an appropriate vector, with the intention of altering gene expression. Currently it is used to prevent, halt or reverse a pathological process. A vector is any 'carrier' or 'vehicle' that can be used to transport the concerned set of nucleic acids into the nucleus of the targeted organism. Depending on the vector, it can be administered ex vivo or in vivo and it then either integrates into the host chromosome or exists as an episomal vector, i.e., sits outside of the main agglomeration of DNA. Gene therapy has three broad

approaches – gene addition, gene alteration and gene knockdown- which are sometimes used in combination.

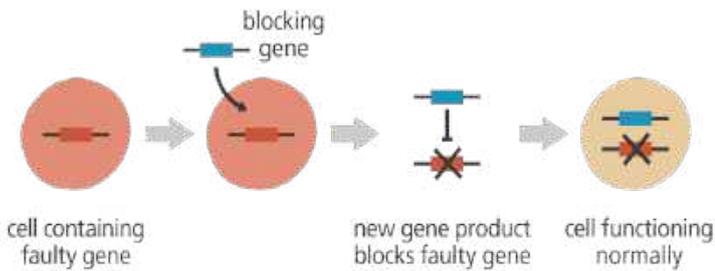
Gene addition is a technique most often used to provide the nucleic precursor to a missing protein. Gene correction or alteration is the alteration of the nucleic acid to that will alter the end protein product. This has gained a lot of attention lately for the use of Zinc Fingered Nucleases(ZFN). ZFNs are simply artificial restriction enzymes that can be designed to cleave a very specific segment of DNA and introduce a site specific gene. These have shown great promise, for example, creating mutations in the C-C chemokine receptor type 5 (CCR5) can make cells resistant to HIV infection. Gene knockdown is a method of virtually eliminating a

gene product. This technique uses, what is known as RNA interference or RNAi. This can be induced by expressing a short hairpin RNA which downregulates the transcription of a certain gene segment by cleaving a specific sequence and hence degrading the target mRNA. MicroRNA sponges are a similar tool, which work in the opposite way. They bind to specific miRNA and reduce their concentration which in turn enhances protein production from the targeted mRNAs.



DID YOU KNOW?
For every pound of fat gained, we add almost eleven kilometres of new blood vessels.

Gene inhibition therapy



Barriers to successful gene therapy

Gene transfer is theoretically a very simple task especially with the conception of gene transfer vectors. However, there are four main barriers that any successful gene based therapy must cross.

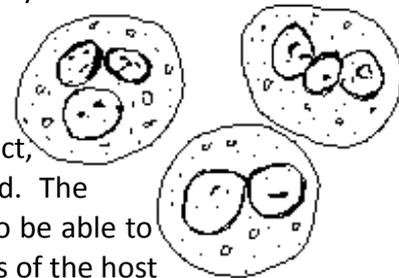
The first is vector uptake, transport and uncoating. This is influenced by many factors such as vascular supply, endothelial barriers to an organ, vector size, interactions etc. Ultimately the ideal vectors would be cell type specific. The engineered vectors are usually too large, unstable or simply unable to progress from the cytoplasm to the nucleus. This is why viruses are used, since they have developed efficient and optimal techniques to enter the nucleus. Retroviral vectors, Adenoviral vector and Adeno-associated vectors have all been developed, each with their individual advantages and shortcomings. Adeno associated viruses are made into vectors by the use of capsid shuffling and directed evolution so as to optimize the transduction parameters of the vector in a manner analogous to the technique known as 'SELEX'. They have been used to great efficacy in improving Leber's Congenital Amaurosis, which is a gene based blindness disorder. Retroviral vectors were also used to cure 5 out of 20 cases of Severe Combined Immune Deficiency in children in the first FDA approved clinical trials of such vectors. As we can see, there is progress in the field in overcoming these barriers.

The second barrier to successful gene therapy is vector genome persistence. Episomal vectors have shown great promise in rats, lasting as active exogenous DNA molecules for up to several years and remain unhindered by cell division. This

maybe because of a slow cell turnover in rats. Vectors that integrate into the host chromosome are the best candidates to solve this problem for cells with a more rapid turnover such as hematopoietic cells.

The third barrier to successful gene therapy is sustained transcriptional expression. The gene, once in the nucleus must be transcribed, otherwise the entire process is rendered useless. The transgene expressions from both episomal vectors as well as integrated vectors can be extinguished by epigenetic modifications. In general, it is best that the duration of transgene expression matches the period of time required to treat the disease. This is either done by vector re-administration for the required period.

The fourth and final barrier is the most challenging one: that of the host cell immune response. The response may be to either the introduced vector which is quite likely as we use viral vectors or it may be to the transgene product, i.e., the protein produced. The biggest challenge here is to be able to predict antigenic responses of the host system. The inability to correlate animal and human studies on this topic makes this barrier even harder to cross. The use of non-viral vectors such as complexed macromolecules containing plasmid DNA molecules is an alternative but they too have their flaws especially owing to limitations in delivery technique.



To conclude, after more than 20 years, we are finally seeing the anticipated therapeutic benefits and some promising preclinical studies. The west is now in the era of personalised genomic medicine, with the cost of sequencing a human genome predicted to further fall from the current \$1000. With advances in sequencing techniques, vector delivery and overcoming the host immune response a new era of medicine has begun to emerge.

CURRENT RESEARCH



Effect of Selenium on Male Reproductive System of Zebrafish (*Danio rerio*)

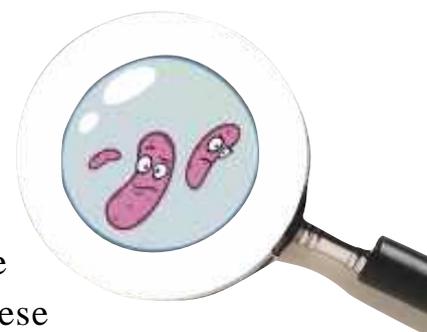
Simantha D'Souza and Dr. Manasi Kanuga

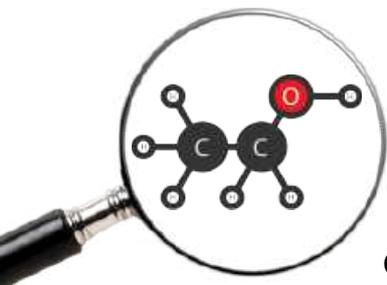
Rapid development of human civilization in the past decade has caused an increase in industrialization. This in turn has led to an increase in the emission of heavy metals into the water bodies, disrupting various functions of aquatic life forms. From the point of view of the male reproductive system in fish, these emissions stimulate the generation of intracellular Reactive Oxygen Species (ROS) that results in spermatozoal dysfunction. Excess ROS production results in sperm plasma membrane and DNA damage which in turn affects fertilization rates and embryonic development. Selenium is a trace element found in various foods and is proposed to exhibit antioxidant properties against ROS and NOS (reactive nitrogen species). This antioxidant property is speculated to act as a mechanism of protection against the toxic effects of heavy metals. This study aims at using zebrafish sperm exposed to various inorganic metals (like Cu, Cd, Zn and Pb) to analyse the proposed protective role of selenium from the toxic effects of these metals which are known to be found in excess in Indian fresh water bodies.

Characterization of Prokaryotic Riboswitches

Student: Nuriyyah Rassiwalla; Guide: Dr. Maya Murdeshwar

The mycobacterial cell wall is majorly composed of mycolic acids. Methyltransferases dependent on S-adenosyl methionine (SAM) are responsible for modifying mycolic acid. These modifications help *Mycobacterium tuberculosis* to retain its pathogenicity, virulence and persistence. The genes required for synthesis of SAM in *M. tuberculosis* are under the control of SAM-IV riboswitch. There is evidence to support that *M. tuberculosis* cannot utilize SAM produced by the host and needs to synthesize its own. Thus, the SAM-IV riboswitch can be a potential drug target against tuberculosis infection. We aim at studying the SAM-IV riboswitch its highly conserved aptamer region that causes suppression of SAM biosynthesis genes. We speculate that this will inhibit the activity of SAM-dependent methyltransferases required for mycolic acid modifications, biotin biosynthesis, and other pathways, leading to rapid killing of the tubercle bacilli. Results might be applied to develop better and effective drugs against MDR-TB (Multi-drug resistant tuberculosis) and XDR-TB (Extensively-drug resistant tuberculosis) as future prospects.





Characterization of bioethanol producing yeasts from various sources

Ketakee Dharmadhikari, Trisha Roy and Dr. Priya Sundarraja
Department of Life Science and Biochemistry, St. Xavier's
College-Autonomous.

Biofuels are fuels derived from living matter, upon carbon fixation according to the International Energy Agency (IEA), Paris, and are a renewable source of energy. Bioethanol is the one of the most widely used biofuel in various countries. Production of bioethanol involves sugar fermentation, the expertise of naturally occurring unicellular eukaryotes, yeasts.

The yeast isolates used for this research have been obtained from rotten fruit sources, namely kokum (*Gracinia indica*) and jamun (*Syzygium cumini*), (three strains from each). Firstly, the morphological and biochemical tests that will be performed would provide a tentative idea elucidating the preliminary characterization of these strains. The pH and temperature tolerance of these strains will be examined to ascertain their tolerance to robust and stressful conditions in order to be used for industrial applications. Since the ethanol production by these organisms is the mainstay of the study, Nitroblue Tetrazolium (NBT) assay will be carried out to determine the quantity of ethanol produced by each strain. Lastly, ethanol tolerance of these strains would also be determined by qualitative and quantitative methods.

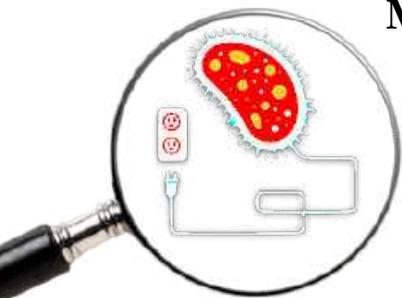
To screen and isolate lipase producers from various sources

Anushree Patil, Dr. Binoj Kutty and Dr. Priya Sundarrajan

Department of Life Science and Biochemistry, St. Xavier's
College- Autonomous.

The present study involves the study of microbial enzyme specifically bacterial lipases. The project's objectives are to screen and isolate lipase producers from sources. The bacterial strains grown on tributyrin media plates which show a zone of clearance indicates the production of the enzyme. The isolates would be observed and studied for their morphological and biochemical characteristics. Further, both qualitative and quantitative assay for the enzyme assay would be standardized. Growth of the isolates at various pH and temperature would be carried out to check for their robustness to grow at varied conditions in order to have industrial application. Lipase being lipid degraders have numerous applications in industries and pharmaceuticals. The project application would aim to use lipases as detergents to clear oily stains and for bioremediation to degrade oil spill.





Microbial fuel cell for sustainable development: Grey-water treatment coupled to generation of electricity and algal biomass

Ryan Martin, Smita Ragade, Binoj C. Kutty*

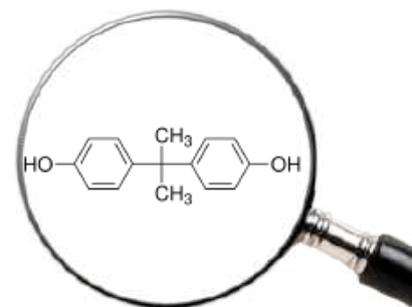
Department of Life Science and Biochemistry, St. Xavier's College.

Microbial fuel cell (MFC) is a recent technology, which uses microorganisms for pollution free electricity generation. Microorganisms growing in the anodic chamber transfer electrons from substrates such as sugars or other organic molecule to a carbon electrode, while at the cathodic chamber, electrons are transferred from the cathode to a final electron acceptor such as oxygen, generating a current. Typically the anode and cathode are separated by a proton exchange membrane or Agar salt bridge. This project involves designing and building a functional MFC and modulating various parameters for optimal performance. This project aims to use Grey-water (domestic waste water) as a substrate in the anode. The cathode in an MFC needs a continuous supply of electron acceptors (O_2), which is traditionally provided by aeration. Growing algal biomass in the cathode can enhance O_2 availability and add as an additional Carbon dioxide sink. The other major objective of the project is to isolate and identify algal strains, which can be grown in the cathodic chamber. Generation of a functional MFC with grey-water treatment in the anode coupled to algal biomass production in the cathode will serve as an excellent model for sustainable and clean energy production.

BPA-induced Toxicity in Adult and Embryonic Zebrafish (*Danio rerio*)

Kajal Jain, Granstel Roberts, Sheetal Perumalla, Dr. Radhika Tendulkar

In most vertebrates, gonadal steroid hormones play a critical role in embryonic development. Differential 17- β Estradiol hormone exposure during the fetal or perinatal period has been shown to be important for vertebrate brain development. Consequently, the potential exists for environmental or synthetic substances such as Bisphenol-A (BPA) to mimic or antagonize the effects of this hormone. BPA is a synthetic compound used to manufacture polycarbonate plastic with global capacity in excess of 6.4 billion lb/year. It acts via the estrogen signaling pathways and causes various health defects involving the nervous, reproductive and endocrine system. It is well documented that estradiol induces cell proliferation and blocks apoptosis during vertebrate embryonic development. However, very few studies involving the effects of BPA on these cellular processes have been carried out, considering the anti-estrogenic action of BPA. In the present study, the effect of BPA and Estradiol on vertebrate embryonic development is being investigated using the Zebrafish (*Danio rerio*) as a model system. Zebrafish embryos exposed to varying doses of BPA/Estradiol are assessed for developmental parameters (and abnormalities if any), cell proliferation and apoptosis. BPA-toxicity studies have also been undertaken in adult Zebrafish.





In vitro and in vivo Analysis of the Effect of Zinc Toxicity on the nervous system

Gloriya Kuttiyath, Jenia Perreira and Bhaskar Saha

Zinc is a vital micronutrient, which modulates the neuroprotective effect it is known to have on the brain. Although several studies have indicated that zinc deficiency leads to neurological dysfunction, studies on zinc toxicity is scarce. We aim to study the differential effects of zinc toxicity on neuronal (Neuro2A) and glial cells by looking at the cell proliferation, survival and other physiological parameters. We also plan to study the effect of zinc toxicity on animal behavior. We will use *C. elegans* as a model organism to study how excess zinc accumulation changes certain behavioral pattern in these animals. Outcome of our study will be able to provide a possible toxicological role of zinc on adult neurogenesis and its related behavioral processes.

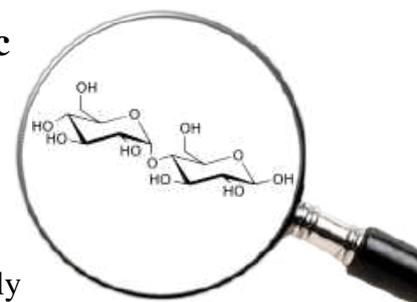
Rapid Detection of Maltase Inhibitory Activity of Antidiabetic Plants

Srushti Chafekar, Vaishnavi Chetiyar ,Janhavi Damani, Joyce Tauro

According to the International Diabetes Federation, the number of diabetic patients in India exceeds that of any other country in the world. Approximately 62 million people in India have been diagnosed with diabetes. There are two types of diabetes: Type 1 and

Type 2. Type 1 Diabetes is seen from childhood, wherein there is a lack or insufficiency of insulin secretion from pancreas. Type 2 Diabetes is an adult onset disease wherein the blood glucose levels to rise higher than normal, called hyperglycemia. There are three different treatment strategies for the treatment of diabetes, viz., insulin therapy, inhibition of intestinal enzymes (amylase, maltase and sucrose), and bariatric surgery.

The objective of the study is to detect maltase inhibitory activity of antidiabetic plant extracts of easily available plants in India, with the help of an enzyme inhibition assay. The leaves, seeds, pulp, or stem of easily available plants such as okra, basil, fenugreek, etc. are the source of the plant extract. Initially, the maltase enzyme shall be extracted from Baker's yeast, which involves the induction of yeast by maltose, a carbohydrate source present in the growth medium. Lyophilization of the crude enzyme extract will also be carried out for storage of the enzyme. Evaluation of maltase inhibitory activity of the plants involves selection of appropriate plant part followed by extraction using appropriate solvent, and subjecting the maltase enzyme to the plant extract in a suitable inhibition assay. Acarbose is a synthetically derived anti-diabetic drug which belongs to the class of alpha-glucosidase inhibitors. It inhibits the intestinal enzyme maltase, thereby, delaying the release of glucose in the bloodstream during carbohydrate digestion and reducing post-prandial blood glucose level in diabetic patients. In this study, acarbose will be used as a positive control whose maltase inhibitory activity can be compared to that of the plant extract. The maltase enzyme activity will be represented as amount of glucose liberated per minute, using maltose as the substrate. The amount of glucose liberated is measured spectrophotometrically using GOD-POD Kit. Ultimately, the aim of this project is to develop a rapid tool to screen for maltase inhibitory activity in anti-diabetic plants, such that it can be conveniently used in rural areas that are technologically challenged. The current digestive enzyme inhibitors used as anti-diabetic drugs have many side effects that have restricted their usage. Therefore, natural products such as plant extracts have attracted the attention of the scientific world for their potential use for treating Type 2 Diabetes.



BIOWAVES 2017- ABSTRACTS

“Mitochondria, just ATP generators or much more?”

Dr. Richa Rikhy, Assistant Professor, IISER, Pune

Mitochondria are famously known as the power house of the cell and important generators of ATP in an aerobic environment. These organelles are thought to have originated from engulfment of bacteria in a cell and have taken over many functions inside eukaryotic cells. This talk will discuss the role of mitochondria in the context of development in multicellular organisms. Metazoan embryos inherit mitochondria maternally. Mitochondria increase in mass after a few divisions in embryogenesis and this is somewhat coincident with cell differentiation. We have been studying the relationship between mitochondria shape, activity and cell differentiation. The results indicate that mitochondria are intimately linked with key events of differentiation and future studies on the mechanisms that regulate this link will elucidate the mode by which mitochondrial functions interact with organism development at large.

“Fitness, Selection and Antimicrobial Resistance in Bacteria”

Dr. Nishad Matange, DST-faculty fellow, IISER, Pune

Antimicrobial resistance is a major challenge faced by the biomedical community today. In particular, the emergence and spread of multi-drug resistant bacteria is likely to set us back by decades in our fight against bacterial infections. Understanding how and why bacteria evolve resistance to antimicrobials is a key step in circumventing this problem. The emergence and spread of drug resistance has been viewed as a process of selection, analogous to natural selection where, under drug pressure, mutant bacteria that are able to grow in the presence of the drug out-compete drug-sensitive bacteria. In line with this model, the emergence of drug-resistant bacteria is strongly correlated with the rampant use, and misuse of antibiotics. However, the processes of selection can be nuanced and whether or not a mutant will be successful in a given environment depends on various factors such as the nature and stringency of the selection pressure and the genetic context. In this talk, I will discuss some of the studies my group has initiated over the past year into understanding how and why certain mutations evolve under certain environmental conditions and what the implications of these studies are from the clinical perspective.

“From LSD to HIV and beyond!”

Dr. Vainav Patel, Head, Dept. of Biochemistry, NIRRH

Our work entails delineating host and pathogenic signatures associated with infection, disease progression and protection against chronic infections such as HIV/AIDS and CMV. The presentation will describe our studies with cellular immune subsets and their association with disease progression in HIV-1 and HIV-2 infected individuals from India. Using multi-parametric flow cytometry to evaluate *ex vivo* frequencies of various T cell subsets such as Treg, memory and activated T cells we document the immune dysregulation present in HIV infection both in Antiretroviral Therapy (ART) naïve as well as treatment settings. The dysregulated CD4+T cell signatures identified were distinct for HIV-1 and HIV-2 indicating disparate pathogenesis. The persistence of these signatures following successful ART (virological control) and correlation with impaired immune recovery (CD4 T cell count rebound) highlight the need for immune modulation as a supplementary treatment modality to enable optimal disease management.

“Computational modelling of biochemical pathways”

Dr. Amar Ghaisas, PhD, Brooks University, Oxford

This project is in the area of “Computational Biology” or “Systems Biology”. Mathematical modelling is a method to study a biological system using computer-aided tools. A mathematical model of any biological system consists of a set of biochemical (or other) reactions – complete with reaction mechanisms, substrate, product, and effector concentrations, enzyme activities etc., specific to the system. Such models utilize relevant experimental data as parameters and/or variables in the reaction equations. In heart, mitochondrial energy metabolism involving utilization of dietary carbohydrates and fats bears a crucial importance for the normal physiological function of the cardiac muscle. The mammalian liver-specific tricarboxylic acid cycle (TCA) model developed within the Cell Systems Modelling Group (CSMG) was used to study and understand the basic functional properties of a tissue-specific TCA cycle model system and to form a knowledge base. Based on this knowledge, we successfully constructed a mammalian heart-specific TCA cycle model using heart-specific enzyme kinetics data from published literature. Analysis of the heart TCA cycle model (HRTTCA) showed that it needs an input from the malate-aspartate shuttle reactions and therefore a mammalian heart-specific malate-aspartate shuttle model was built. Analysis of the malate-aspartate shuttle model revealed that in order to supply the heart TCA cycle with anaplerotic input, the cytosolic NADH/NAD⁺ couple must vary dynamically and therefore a glycolysis model was built. Once, all the models were studied in detail, the three were combined to form a fully extended model of heart TCA cycle. Structural analysis of the fully extended model shows that there are more than 278 elementary modes in the extended model that use different combinations of 37 reactions. Kinetic analysis of the model shows significant findings that reveal its response to changes in various enzyme activities. This project will lead to improved understanding of the responses of mammalian heart mitochondrial metabolism to perturbations such as varying cellular demand for energy (ATP) and substrates (e.g. Pyruvate (Pyr)). The invaluable addition of Malate (Mal)-Aspartate (Asp) shuttle reactions as well as glycolysis reactions has hopefully generated a more physiologically relevant model system. In future, we plan to adapt the simulation to represent the dynamics of hyperpolarized ¹³C labelling, using the experimental data generated with hyperpolarized ¹³C Pyr as a metabolic tracer. This enables non-invasive, real-time visualization of the biochemical mechanisms under normal as well as abnormal conditions.

“The ISHKonnect Study on MSM”

Mr. Pallav Patankar, Director of Programs, Humsafar Trust, Mumbai

The Internet is a rapidly emerging technology used by Indian men to meet casual male sex partners, posing a new challenge to India’s HIV-prevention efforts. Most Indian HIV interventions are based on physical cruising sites. Thus MSM who use the internet for cruising often fall beyond the purview of these interventions. Further, limited studies have attempted to explore risk behaviours of MSM who seek sexual partners on the internet. Thus, we do not know the extent of vulnerability of MSM who use internet to seek sexual partners. The broad purpose of this study is to conduct formative research, identifying the HIV prevention needs of MSM who use the Internet to seek sex with men and differences in their online and offline sexual behavior.

Extraction and Qualitative Identification of Papain from *Carica papaya* Latex Using a Simple Technique and Assay Developed in an Undergraduate Laboratory

Farha Ansari, Lakshmi Hiranandani, Ananya Somani, Harshad Parekar, Parmeshwari Chandak, Akhil Kumar, Merlyn Cherusserikaran, Dean D'Souza, Rebecca Diya Samuel, Karen Gonsalves

Department of Life Science & Biochemistry, St. Xavier's College (Autonomous), 5, Mahapalika Marg, Mumbai-400001, India.

Abstract: *Papain, a cysteine protease, also known as Papaya Proteinase was extracted from papaya latex by making incisions in the skin of raw papaya fruit. Papain thus extracted was compared to commercial papain in terms of its electrophoretic mobility and qualitative activity in agglutination tests.*

Keywords: Papain, Papaya Latex, Native-PAGE, Agglutination.

INTRODUCTION

G.C. Roy, first recognized the importance of enzymes present in *Carica papaya* (Papaya) latex published his work in 1873^[1]. The enzymes present in papaya latex are a mixture of proteolytic enzymes including papain, chymopapain A, chymopapain B, endopeptidase papain and endopeptidase omega^[7, 9]. Papain (EC.3.4.22.2) belongs to the family of cysteine proteases and was first extracted from crude dried latex of papaya. Papain has a molecular mass of 23,406 Da and structurally consists of a single polypeptide chain with three disulfide bridges and sulfhydryl groups for enzyme activity^[2,3]. It is most widely used as meat tenderizer^[4] and has several other applications involving defibrinating wounds, treatment of edemas, and as a cleansing agent for contact lenses^[5,6]. Papain was first used in 1959 by Rodney Porter and Gerald M. Edelman to determine the structure of the antibody molecule^[4]. It was found to cleave immunoglobulins into three fragments, two of which were identical and bound the antigen (Fab - Fragment antigen binding), while the third did not (Fc - Fragment crystallized).

The present work focusses on standardizing a protocol for the extraction and isolation of papain from dried papaya latex in a regular, unsophisticated undergraduate lab, and to develop a new assay to qualitatively determine papain activity without the use of expensive and specific substrate molecules. It makes use of the property of papain in digesting the antibody IgM and rendering it ineffective against binding to blood antigens, resulting in the loss of the agglutination reaction^[4].

MATERIALS AND METHODS

Extraction of Papain: Latex was extracted from raw papayas sourced from Vasai, Colaba, St. Xavier's College campus (Woods, Gate) and Bhiwandi. Incisions were made in the skin of the raw fruit using a surgical blade (**Fig.1**). The extracted latex was microwaved for 30 seconds, and scraped till a powder was obtained. Papain was extracted from the dried latex using a modified method^[1] 2.5g dried latex was dissolved in 25ml of 20mM cysteine-HCl containing 1mM EDTA and stirred for 20 minutes on a magnetic stirrer following which the pH was adjusted to 9.0 using 0.1M NaOH. The pellet obtained after centrifugation (11,800 rpm, 4°C, 30 min) was discarded and solid (NH₄)₂SO₄ was added to the supernatant for 45% saturation and stirred for 20 minutes under cold conditions. This solution was centrifuged as above and the supernatant was discarded. The pellet was dissolved in 25ml of 1mM EDTA and solid (NH₄)₂SO₄ was added to the solution for 40% saturation. The solution was centrifuged as above and the supernatant was discarded and the pellet was dissolved in 25ml of 0.1M phosphate buffer containing cysteine-HCl, pH 7.5, and 2.5g solid NaCl was added. The solution was stirred for 15 min under cold conditions and centrifuged as above. The supernatant was discarded and pellet dissolved in 10ml of 0.1M phosphate buffer containing 20mM cysteine-HCl and 1mM EDTA, pH 6.5, incubated at room temperature for 30 minutes and stored at 4°C for 48 hours.

After 48 hours the solution was centrifuged as above and the pellet (crystals of papain) was stored at 4°C in 0.01M sodium acetate buffer, pH 5.0. The above extraction was carried out twice and yielded two pellets henceforth referred to as Extracted Papain-1 (from trial 1) and Extracted Papain-2 (from trial 2).

Native PAGE: Native PAGE or non-denaturing discontinuous gel electrophoresis was performed by the method of Reisfield *et al*^[8] for basic proteins, using a 10% polyacrylamide gel run in 0.25M Tris-Glycine buffer, pH 8.3, at 102V for about 2.5 hours (till the tracking dye reached bottom). The gel was then stained with staining solution (0.125% Coomassie-Blue R-250, 50% methanol, 10% acetic acid) for 1 hour, followed by destaining in 50% methanol, 10% acetic acid for about 2 hours with constantly changing destaining solution at intervals of 30 minutes (till the background became nearly colorless).

Microscopy: Crystals of Extracted Papain-1 and Extracted Papain-2 were compared with that of Commercial Papain (Loba Chemie, Mumbai) under a compound light microscope (Olympus), under 10X and 40X magnification.

Agglutination Tests: The assay was conducted in a number of steps, with varying factors that included the use of Blood of type A obtained from blood bank of G.T. Hospital, Mumbai, and different reagents (commercial papain, extracted papain), varying treatment times, temperatures of incubation, and dilution of antibody added (3.7 mg/ml Anti-A manufactured by Tulip Diagnostics Pvt. Ltd., Goa). The mixtures of antibody and papain were prepared in microfuge tubes wherein activation mixture containing 0.5ml of 0.1M phosphate buffer pH 7, 10µl of 1mM cysteine-HCl and 10µl of 1mM EDTA was added wherever necessary^[4]. The following were studied: 1. Spontaneous effect of varying concentrations of commercial papain on the agglutination of antibody; 2. Spontaneous effect of extracted papain on agglutination of concentrated antibody (3.7 mg/ml); 3. Spontaneous effect of extracted papain on agglutination of diluted antibody (0.37mg/ml); 4. Effect on agglutination of diluted antibody treated with papain for 48 hours; 5. Effect on agglutination of intermediate concentration of antibody treated with papain for 48 hours.

RESULTS

The two pellets obtained from the extraction procedure were analyzed for the presence of papain by native PAGE run, microscopic analysis and agglutination tests.



Fig.1. Extraction of papaya latex. Incisions were made in the skin of the fruit with a surgical blade and the latex collected.

Distinct protein bands were observed in the Native PA gel (**Fig.2**) with bands in lanes 2 to 5 (extracted papain), corresponding to the band in lane 1 (commercial papain). This confirmed that the crystals extracted from papaya latex were crystals of papain, or a protein with similar electrophoretic mobility. The antibody digests, i.e. lanes 7 to 10 could not be accurately detected on the gel.

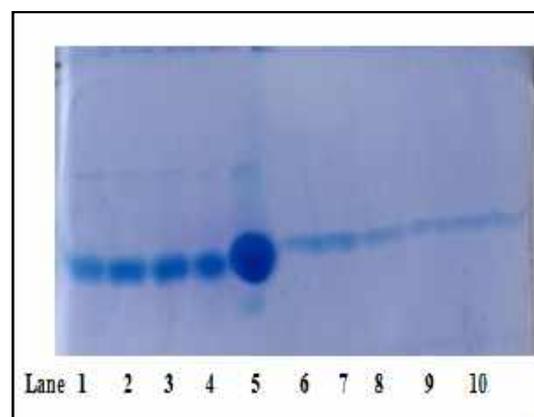


Fig.2. Native-PAGE gel.

Lane 1: Commercial papain.

Lanes 2 and 4: Extracted papain (trial 1).

Lanes 3 and 5: Extracted papain (trial 2).

Lane 6: Antibody (Anti-A Ab).

Lane 7: Antibody digested by commercial papain, incubated at 37°C.

Lane 8: Antibody digested with extracted papain (trial 1), incubated at 37°C.

Lane 9: Antibody digested with extracted papain (trial 2), incubated at 37°C.

Lane 10: Antibody digested with extracted papain (trial 2), incubated at 4°C.

Microscopic examination of the extracted crystals under 10X and 40X of the compound light microscope was not conclusive (**Fig.3**). The crystal structure could not be observed. It yielded information pertaining to the crude properties and color of the extract.

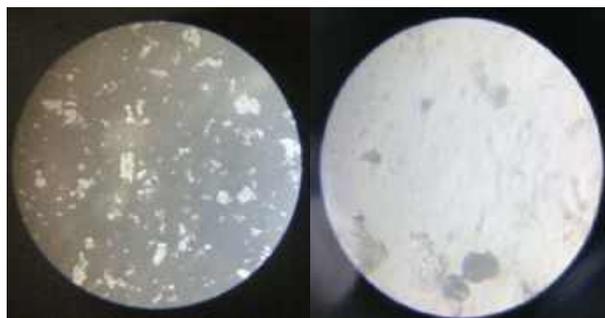


Fig.3. Microscopic Analysis of Papain Crystals.
a. Under 10X. b. Under 40X. No structural features could be identified clearly.

The extracted papain had little to no effect on the antibodies in the preliminary agglutination assays carried out. This might have been due to the high concentration of antibodies used against the small amount of protease extracted, or very short incubation time (spontaneous effect of extracted papain could be negligible). On performing several standardizations with respect to the concentration of papain, dilution of the antibody and incubation time, it was observed that increasing concentration of extracted papain showed decreasing agglutination, and showed less agglutination as compared to the control (**Fig.4**).

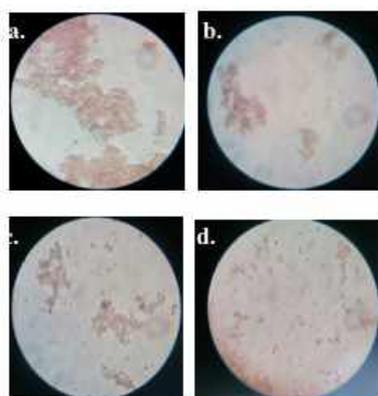


Fig.4. Agglutination Assays. a. Control. No Papain added. Agglutination observed. b, c, d. Increasing concentrations of papain added, showing decreasing agglutination.

DISCUSSION

Papain was extracted by a method modified from the original method^[1] in that the concentration of 65mg/ml of protein wasn't maintained, refrigeration time of 18 hours was exceeded to 48 hours, smaller volumes of buffers were used instead of the ones specified, stirring time of 15-20

mins was shortened to 5-10 mins as the latex amount obtained was low. Additionally, the use of Cysteine-HCl instead of Cysteine might have caused some changes in the activity of papain obtained due to pH changes. Also, the dissolution of latex in cysteine solution was achieved through magnetic stirrer instead of the traditional method of crushing along with sand in the solution. These modifications might have led to the ambiguous microscopic results, although the extracted papain showed proteolytic activity. Thus, the extraction of papain was standardized in a simple undergraduate laboratory set up using available chemicals and infrastructure.

ACKNOWLEDGMENTS

The authors would like to thank the Department of Life Science and Biochemistry for providing the equipment and chemicals for the project. Dr. Nandita Managlore, Mr. Prashant Ratnaparkhi, Dr. Maya Murdeshwar and Dr. Bhaskar Saha are thanked for their guidance, and other members for discussions and help.

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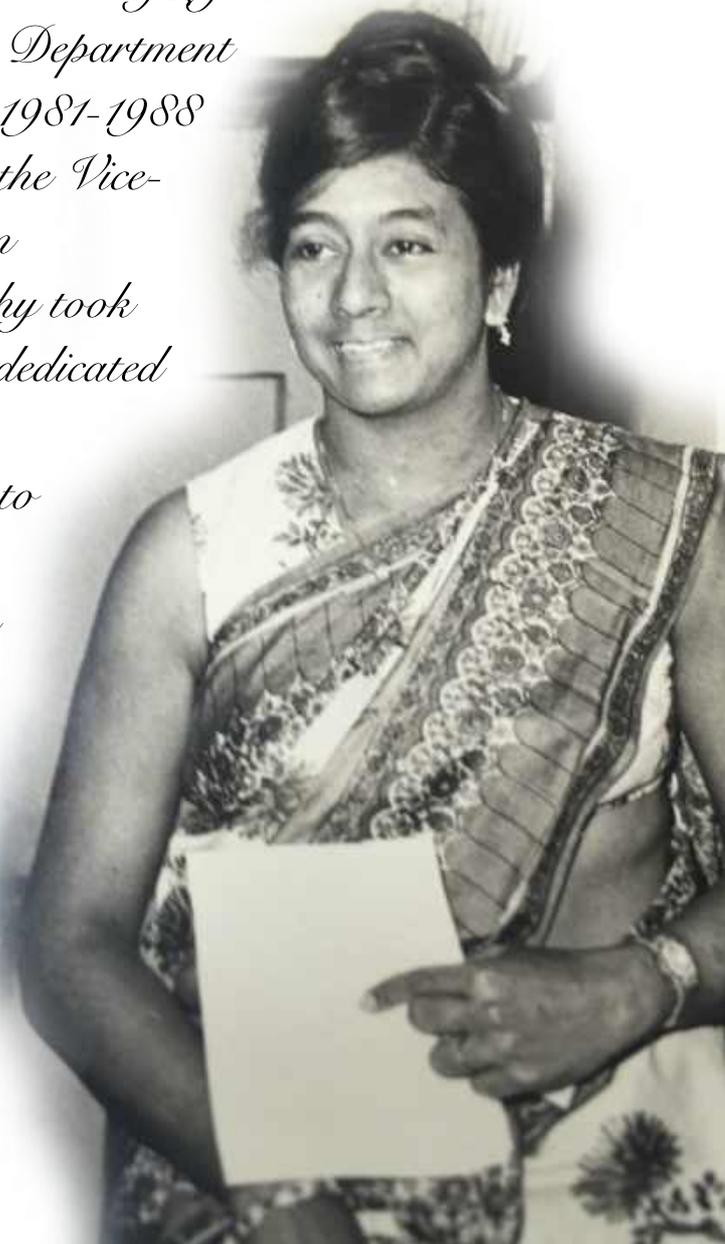
In Remembrance of a Dear Friend

Dorothy Hakim (1947-2016)

Dr. Dorothy Hakim (nee Solanki) a National Swimming Champion of India, joined St. Xavier's College in the year 1973 as a Lecturer in the Department of Zoology. In 1978, Dorothy took the opportunity and moved to the newly established Department of Life Sciences. She served as the Head of the Department of Life Science and Biochemistry from 1981-1988 and again from 1990-1992. She was the Vice-Principal Junior College from 1984-1987. In June 1996, Dorothy took voluntary retirement after 23 years of dedicated service.

Dr. Dorothy Hakim dedicated her life to teaching and cared deeply about education, environment, health, science and technology and most importantly children.

Dr. Dorothy Hakim breathed her last on 25th July 2016 in her daughter's home in Malibu, California at a young age of 69.



THE TEACHING STAFF

Photo courtesy : Jinali Mody



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Assoc. Professor (MSc, MPhil, PhD)

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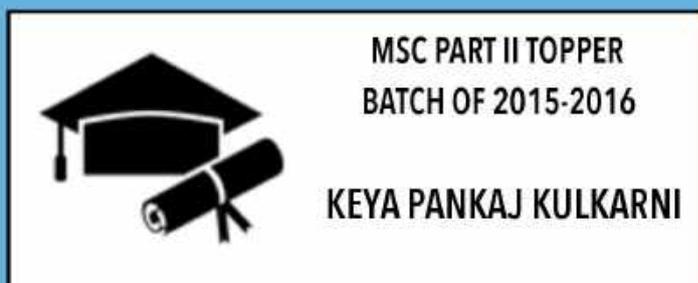
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