XAVIER'S ASS0CIATION OF CHEMISTRY

Presents

THE ELEMENTAL

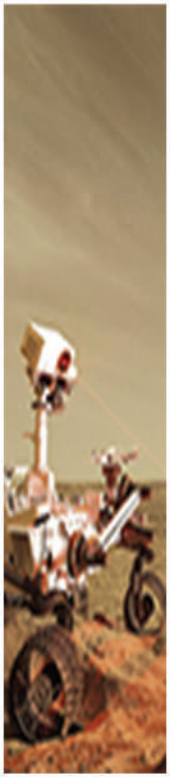
2017 - 2018

Department of Chemistry

St. Xavier's College (Autonomous), Mumbai

INSIDE








Professors- In- Charge

Dr. Ashma Aggarwal

Prof. Marazban Kotwal

Dr. Pralhad Rege

Teachers' Note

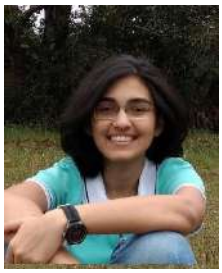
I am pleasantly surprised and in-fact quite impressed by the very apt theme - 'Interactions', chosen for this edition of Elemental – the Chemistry Department magazine.

From the very moment of its conception to the present age, our universe and all the life forms – unknown as well as known to human kind are the results of 'Interactions' that have either happened or are still going on between each other, leading to continuous evolution. It is these 'Interactions' that we owe our existence to. With fast growing advancements in Science, a chemist is able to provide an inside view of such complex interactions taking place at every level.

Xavier's Association of Chemistry- Popularly known as XAC, has evolved to its present form as a result of intellectual and constructively creative interactions between our dedicated XAC students and faculty members of various streams. Each year, the Student Core Committee plans activities running through-out the year, keeping in mind topics relevant to current areas of research, new scientific discoveries and much more. This magazine is one such effort to reach out to more students and make them aware of the beauty of Science from a chemical perspective.

I wish the whole XAC team the very best.

Dr. Ashma Aggarwal



Editor's Note

Aarti Jaswa, TYBSc

Our world as we know it is functional because of interactions that exist between entities. Chemistry as a scientific discipline is the study of interactions. Be it between atoms or molecules at the microscopic level or between the elements on the scale of the planet that together constitute nature. The universe is teeming with interactions and therefore with chemistry. Different scientific disciplines and fields study these interactions at different levels and in different contexts.

A neuroscientist studies interactions between cells and chemical neurotransmitters in the brain are what keep us thinking, breathing and feeling. Whereas, a biologist studies cells as units of life that contain DNA and a myriad of different proteins and other molecules interacting with one another. An astrophysicist would study interactions between matter and energy in the cosmos while a material scientist would study interactions of the different components that make up matter and give it characteristic properties. Chemistry provides a foundation for understanding these interactions and phenomena at a fundamental level.

This year's theme for our magazine is titled, 'The Interactions that Create Chemistry'. The 'Elemental' symbolises the significance of interactions in creating and moulding all that exists as it does today. Join us as we explore them from a variety of perspectives and appreciate their simplicity and importance in the complex fabric of the universe.

Then and Now

Perspectives from Professor Himanshu Gupta and Druhi Vaid (TYBSc)

The academic year 2017-2018 marks 15 years since the Xavier's Association of Chemistry came into being. We are fortunate enough to have with us as part of the faculty of the Department of Chemistry, one of its founding members, Professor Himanshu Gupta. The following is a message from him about his experience as secretary of XAC, now looking as a professor in the department...

The seed of XAC which was sown by us, has now developed as a tree. It has become a tree of knowledge and provides opportunities to develop the skills of every student in the field of chemistry. I feel proud when I see the dedication of all the enthusiastic members of the committee in planning and executing all the events.

XAC was the closest association to me when I was the student at St. Xavier's College. As students of the chemistry department we wanted to start an association to serve our students in the best possible way. The formation of this association faced many difficulties, but with all the support of our staff members, finally XAC was formed. I feel really fortunate to have had the opportunity to serve as the secretary of XAC in its inaugural year.

Back then, my vision as a secretary of XAC was to publicize Chemistry as a subject and to create an awareness of the scope of the subject among students. I wanted this association to help students who had difficulties in the subject by organising sessions with various scholars. To make the subject more interactive, we started having various innovative activities and special events such as "Chem-housie", "Spell-C" and many more. The XAC fest was one of the most awaited moments for all the XAC members. This gave the members as well as the students an opportunity to work as a part of the association and for the association in multiple different activities like "Chemistry Treasure Hunt", "Chem-Quiz" and several others.

When I look at the work of the current committee and all its energetic members, it seems that the vision we had while forming XAC is being fulfilled.

Earlier as a student and now as a faculty member I will always strive to be there to help this association in every possible way. Lastly, I take the opportunity to wish all the members best of luck for all the work that they are doing for XAC and hope that they will continue to keep the flame burning which was lit by us.

Druhi Vaid from TYBSc Chemistry is the Chairperson of XAC this year. She has been an active member since her FYBSc in 2015. The following is a message from her about her journey as a part of XAC and her experiences going from member of the association to leader of the core committee:

Chemistry is a beautiful science that bridges various aspects of life together. It is not an isolated subject, rather it always works in alliance with other sciences to give rise to life, death and everything in between. XAC has played a phenomenal role throughout my college life. It instilled a sense of pride in me to be learning, understanding and exploring such an exciting discipline. XAC has not only strengthened my knowledge of the subject but has also given me a chance to explore its omnipresence. It has given me the opportunity to interact with wonderful people who were once where I am, being students with an ambition to one day become a scientist. Their stories, their hardships and their achievements have left me awestruck and has motivated me to achieve my goals one day.

Back in 2015, as a first-year student, I had the chance to represent St. Xavier's College in various intercollegiate competitions and events on the behalf of XAC. I remember winning some events and losing twice the amount. But, what I remember more clearly is the response I got from the XAC core team members for my efforts. They were incredibly appreciative and made a huge deal about me winning a small-scale poster making competition. The ambience of XAC, the professors of the Chemistry Department and my desire to become as loving, efficient and smart as my seniors are only a few of the reasons I wanted to become the XAC Chairperson. XAC made me realise the importance ofz team work and taught me how to appreciate opinions, especially those that conflicted my own. I am proud to say that I can now use the statement, "I stand corrected", while feeling no shame. With the help of XAC, I along with many other students have been able to give back to the society by hosting interactive sessions revolving around Chemistry with students of Municipal schools. This beautiful initiative made me feel like I was doing something worthwhile, it made me feel like I was making a change.

The best part about XAC is that it is an initiative by the students with the professors acting as a strong backbone. This gives them the resources and the opportunity to discover the integrities of science as independent individuals. It is not an association that spoon feeds its students, but it acts as a guiding light for them to achieve great heights. I have XAC to thank for a lot, especially for the friendships that I have strengthened along this journey. From working with my fellow core team members, to volunteers, the professors of the Chemistry Department and the kakas of the Chemistry lab, I will be leaving this college with a bag full of memories, most of them centred around this extraordinary association.

In Conversation with Dr. (Fr.) Roy Pereira S.J.

- Aarti Jaswa
TYBSc

Fr. Roy has been a part of St. Xavier's College for a total of 36 years. He joined in 1980 as a student and graduated with a double major in Physics and Chemistry. This year marks his 25th year as a part of the faculty of the Chemistry Department. Along with being the director of the Xavier's Development Programme and the Vice-Principal (Academics), he is currently Head of the Department of Chemistry.

He describes his journey going from student to teacher and finally to Head of Department as an interesting one. After graduating, he completed his MSc in Inorganic Chemistry at the Institute of Science before joining the Jesuits and becoming a priest.

During his MSc, he also worked as a part of Bombay Theatre with renowned theatre personalities and artists including Alyque Padamsee, Sharon Prabhakar and Shiamak Davar. The experiences and skills he acquired during this time, he uses till date in his interactions with the current youth. One note worthy observation is that he has made over the years is that, when he joined the department as a teacher, his senior professors were the same people who taught him as a student. Now, as head of the department, he sees that some of his own students have joined as teachers.

Pursuing Neuroscience is what Father Roy considers the most exciting journey of his life. After conducting a small meditation session in one of his lectures, he noticed that about 100 agitated and distracted students transformed into a silent and attentive class. This experience, along with his keen interest in yoga and meditation is what drew his attention towards the power of the mind and the patterns of the brain. He completed his PhD in Neuroscience in Boston, during which, he received a scholarship to Harvard University for a semester to study Mind-Body Medicine.

"Many say that Neuroscience and Chemistry are quite far apart. But, they aren't so distant because Neuroscience deals with the Chemistry of the brain", says Father Roy.

He recently completed a post-doc in the USA on receiving two scholarships, the first from UC Berkeley and the second from St. Louis, Midwest. He worked on studying the effects of social media and mobile phones on the brain and its patterns. While at UC Berkeley, he was invited to give a talk at the Google Headquarters. He was also invited to Harvard University to speak about meditation and health outcomes from practicing yoga and meditation when he was at St. Louis.

Having studied and done research work abroad, his advice to students wanting to do the same is firstly, to start preparing early. The preparation itself is tedious and getting everything in place including transcripts, SOPs, letters of recommendation, and so on is necessary. Secondly, to apply to universities strategically. Making sure that you're applying to ivy league, mid-level and even a few smaller universities as it increases your odds at securing admission. Lastly, it's worth giving the department or faculty of a particular university more weightage than the actual university while applying. Finding guides and peers focussed on same areas of research as your interest is valuable and enables better learning.

As a professor of an interdisciplinary field like Neuroscience, Father Roy advocates for students and teachers alike to bridge the gap between different subjects. Different departments in institutions are divided by artificial divisions. In order to be at the frontier, one needs to be interdisciplinary; looking in different directions and through different perspectives to truly get an essence of the bigger picture.

The Chemistry of Cooking
- A Talk by Chef Joshua D'Costa

-Varun Rawal
TYBSc

Joshua D'Costa is a co-founder and executive chef at Urban Nashta, a breakfast delivery service. He used to be a chef at Bombay Canteen, Kamla Mills, Lower Parel and also spent his time working for other food companies before becoming an entrepreneur. Urban Nashta provides its customers with a healthy, wholesome and delicious breakfast. Their rotating menu ensures that you get a beautiful variety of breakfast options on the go. They're based in Powai and currently cater to areas nearby. He was invited by the Xavier's Association of Chemistry (XAC), St. Xavier's College to give a talk on the 28th of November, 2017.

Per Chef D'Costa, many may argue and say that cooking is art but at its core there is a lot of science and chemistry involved. The same is true when it comes to tasting food. Tasting is a complex process involving all your senses. You don't only taste with your tongue, all your other senses viz. smell, touch, sight and sound are involved.

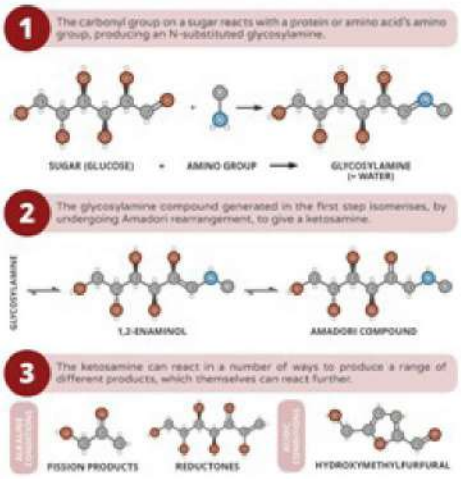
Smell is definitely a main player when it comes to your dining experience. There are 2 ways by which one can smell. The first is orthonasally (through the nostrils) and the second is retronasally (through the throat). In the case of the latter food particles land at the back of your tongue, making you actually taste it. This is why one may describe a smell as sweet, but the sweetness is really a taste associated with sugary foods.

Touch or tactile sensations in the mouth go hand in hand with taste. The structure and texture of a food or a drink influences the way volatile compounds are released in your mouth, "For example, all you Beer drinkers out there, know how bad a flat beer tastes". Most studies have found that food hardness generally increases the perceived taste. The way a particular food or beverage is delivered to the mouth can also influence perceived flavour. For instance, some research shows that different metals associated with cutlery can alter the perceived taste. No wonder everything tastes better out of a Silver Spoon!

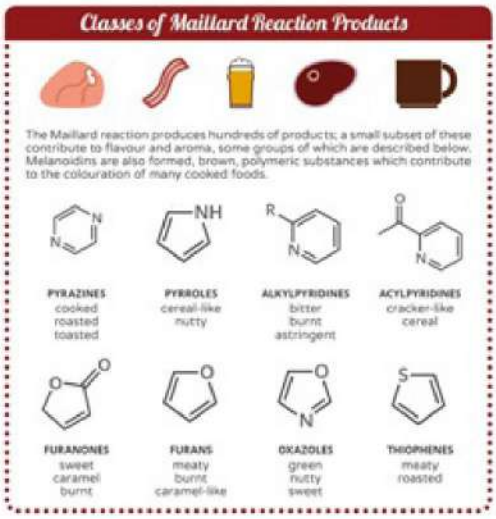
A lot of what you see influences how you taste. The presentation of a meal not only affects how much you expect to like the food, but also your actual sensory experience with it. Research suggests that the colour of a food or beverage makes them taste a certain way. One such experiment showed that adding red colour to a sugar solution increased its perceived sweetness in comparison to a clear solution. This was because the subjects associated the colour red with cherries, strawberries and other red, sweet fruits. Another study showed that colour impacted the refreshment levels in different beverages. They concluded in this case, that clear solutions provided a greater degree of refreshment. Food and beverages make various sounds inside the mouth and during mastication (chewing). Like other senses, one associates certain sounds with certain foods. These also influence one's perception of flavour.

He went on to discuss the five basic tastes that humans can distinguish i.e. sweet, sour, salty, bitter and umami. This is based on the information that is transported from the tongue to the brain. Many dishes are made up of a combination of these

What we perceive as sweetness is usually caused by sugar and its derivatives like fructose or lactose. However, amino acids and alcohols can also stimulate the sweet taste receptors. Sour taste receptors are stimulated by H+ ions in acidic solutions like lemon juice or organic acids in water. Ions present in salt crystals are responsible for the perception of salty tastes. Bitter tastes can be brought about by many fundamentally different substances. In total there are about 35 different proteins in the sensory cells that respond to bitter substances. From an evolutionary standpoint, recognizing poisonous bitter species of plants was a matter of survival. Lastly, the umami taste, which is described as savory, is usually caused by glutamic acid or aspartic acid. These two amino acids are part of many different proteins found in food and even plants. Ripe tomatoes, meat and cheese all contain a lot of glutamic acid. Asparagus, for example, contains aspartic acid. Chinese cuisine uses glutamate, the glutamic acid salt, as flavor enhancers. This is done to make the savory taste of foods more intense. 'Spicy' is not a taste although, it is often described to be one. It is, in fact, a pain sensation signal sent by the nerves in response to the chemical capsaicin.



"The Maillard Reaction forms one of the most significant aspects of food chemistry.", says Chef D'Costa. It was given its name in honour of Louis-Camille Maillard, who first described it in 1912. It is the reaction between an amino compound (an amino acid, peptide, or protein) and a carbonyl compound (usually a reducing sugar, such as glucose) resulting in the browning of food. There are two main types of mechanisms by which the browning occurs, depending on whether enzymes are present or not. Enzymatic browning would be seen in the case of an overripe banana, while non-enzymatic browning would be seen in a freshly baked loaf of bread. Non-enzymatic browning is divided broadly into three types of reactions. The first being the Maillard reaction and the second being caremelisation. In the latter, the sugars react on their own and at higher temperatures compared to the former. The third is ascorbic acid oxidation.



The Maillard reaction is incredibly complex. A simple example such as the reaction of glucose with ammonia, using simple methods, gives evidence of the formation of more than 15 compounds. The reaction of glucose with glycine gives more than 24. The Maillard reaction is exceptionally widespread too. It occurs virtually ubiquitously in foodstuffs, particularly during processing at elevated temperatures (roasting, baking, extruding) or during storage for prolonged periods. It is important in the manufacture of reaction flavours, coffee, and chocolate. The changes that it brings about in food have both nutritional and toxicological effects. It even has important medical implications, since it occurs in the body.

The first overall transformation pathway for the Maillard Reaction was Proposed by John. E. Hodge in 1953 and is still widely accepted. Since the compounds involved in the reaction are present in virtually every cell, the ramifications of the Maillard reaction are almost boundless and understanding it is of fundamental importance to food science and to the functioning of living cells.

Decoding The Ancient Martian Atmosphere

- Ritabrata Mitra
FYBSc

Maybe now or maybe later after dusk, walk up the staircase to your terrace and stand there for a while. As you move your eyes across the night sky, you are bound to encounter a bright red object capturing your attention and freezing your senses. Congratulations! Now, you belong to the same clan that made the same observation thousands of years ago, along with the ancient Egyptians and Greeks. But hold on a minute, it's the 21st century, right? We can actually take a step further and use a bit of chemistry and try to decode what Mars really has to offer.

Since we have taken the plunge, let's start from scratch... Why does Mars appear red? Most of the rocks on the Martian surface are full of Iron, which in due course of time oxidizes and turns reddish. Mars is also frequented by violent dust-storms which kick the loosely bound particles on the rock surfaces and shoot them into the air. As a consequence, the planet is covered in an envelope of red smoke.

With that in mind, let's address a more serious question: Is Mars habitable? At present, definitely not. Automatically, the curiosity engines put another question on the table: Was Mars habitable anytime during its past? The answer to this question is a daunting YES! Let's try to assemble the pieces in the jig-saw puzzle.

There are incredible outflow channels on the Martian surface that indicate the presence of flowing water. Where one finds liquid water, there is an extremely high probability of finding life forms. So, what happened to this liquid water? Mars had to be warmer than what it currently is to sustain water in its liquid form . The solar radiation is not productive to discuss because during the Noachian (Geological term designating the early phase of Mars, about 3.5 billion years ago) the solar constant was only 70% of what it is today. That leaves us with the conclusion that the green-house effect would have been operating at that time. Currently however, Mars doesn't have an atmosphere. So, how do we explain such a conclusion? Well, the theory goes that Mars had an ancient atmosphere which it subsequently lost.

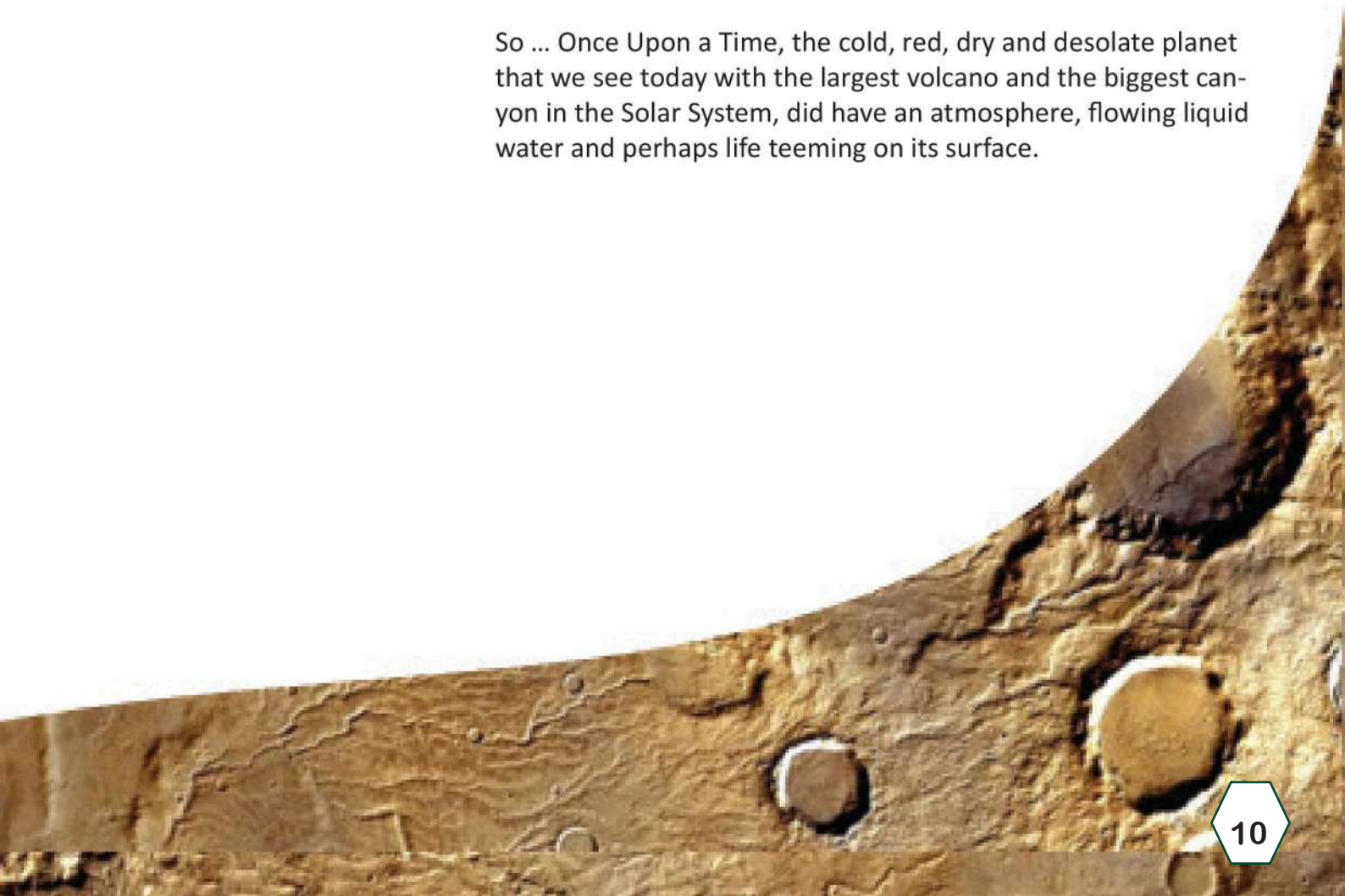
There are a lot of particles in random motion in the upper part of a planet's atmosphere. When highly energetic UV photons, brought about by a solar wind, hit these particles it charged them by displacing electrons. On Earth we call this layer the Ionosphere wherein it is held by the Magnetic Field of Earth, not allowing the particles to escape into the space. Mars lacks its own Magnetic Field which made it easier for the solar wind to blow away the charged particles, thus gradually depleting its atmosphere.

The solar wind during the Noachian was 200 times stronger than what it is today. The next logical question is: How do we verify that such a process had taken place?

During such a spluttering the lighter atoms would be blown away considerably leaving behind the heavier ones. We consider two isotopes of Argon, $^{36}Ar_{18}$ and $^{38}Ar_{18}$. Why Argon specifically? Because it is an inert gas and mainly sits in the atmosphere minding its own business, making it the perfect candidate for this job. We had earlier found out that the $^{36}Ar_{18}/\ ^{38}Ar_{18}$ ratio on Jupiter and Sun were both roughly equal to 5.5. Since these two are primordial components of the Solar System they can be treated as the standard. So, when the Curiosity Rover landed on the Martian Surface, one of the first things it did using its Mass Spectrometer was analyse the Martian air.

The Rover found that the $^{36}Ar_{18}/\ ^{38}Ar_{18}$ ratio turned out to be 3.5, two notches below the primordial standard. This meant that the heavier isotope $^{38}Ar_{18}$ is present in a much larger amount than the lighter isotope $^{36}Ar_{18}$, establishing the imbalance predicted during the loss of the Martian atmosphere. Another probe called the MAVEN (Mars Atmosphere and Volatile Evolution Mission designed to study the Martian atmosphere while orbiting Mars) was later sent to analyse the rate at which Mars was losing its atmosphere. The results turned out to be pretty impressive and were in sync with the Noachian predictions.

So … Once Upon a Time, the cold, red, dry and desolate planet that we see today with the largest volcano and the biggest canyon in the Solar System, did have an atmosphere, flowing liquid water and perhaps life teeming on its surface.



In Conversation with Dr. Arnab Bhattacharya

- Medeline Joseph, SYBSc & Ruru Thakur, FYBSc

Dr. Arnab Bhattacharya is a man of many accomplishments and his contribution to science has not gone unnoticed. With a B.Tech degree and a Ph.D. in physics, he is one of the pioneers in the field of semiconductor optoelectronics at the Tata Institute of Fundamental Research (TIFR) in Mumbai.

His work has focused on III-nitride semiconductors. Working on combining trimethylgallium with arsine and trimethylgallium with ammonia to give gallium nitride and methane. Simultaneously, controlling the reactions to nanometer scale thickness and changing the colour of light emitted by the materials. Broadly speaking, Dr. Bhattacharya works to combine elements to create compounds that emit light. This is because silicon, while a commonly used element in semiconductors, absorbs but doesn't emit light. To create these compounds, elements from groups 3 and 5 are used (such as gallium and arsenic) to give a structure that is similar to germanium but emits light.

However, it is not easy to grow materials in a single crystal form in a particular orientation. At TIFR, Dr. Bhattacharya studies and tries to understand the nature and working of these materials, and how exactly they emit light.

Single crystal semiconductor nanowires (with a particular crystal orientation) are another important part of their research. To work with semiconductors, scaling things down is critical. This is where nanotechnology comes in, making the layers of semiconductors as thin as possible for the wave properties of electrons to affect their working.

Per Dr. Bhattacharya, it is more challenging to be an experimentalist in India than a theorist simply because a lot of the equipment and chemicals required for your research are not available here. However, things have improved drastically in the last decade or so. Over the last 15 to 17 years, with the development of the internet, we have more access to information than ever, dramatically changing all aspects related to research. While basic research is difficult to get funding for, scientists at TIFR are very well funded, making it easier for them to work without any hindrances.

Dr. Bhattacharya's hobbies and interests are numerous, and include photography, cooking and outdoor sports, to name a few. The sound manager and occasionally backing vocals for a band ("The Conduction Band") at TIFR, and a marathon participant, he is a man of many talents and passions.

Dr. Bhattacharya had no shortages of role models as scientists in his family. One of his uncles was a chemistry professor, and allowed him to perform experiments in his laboratory, which gave rise to his love for chemistry. Another uncle of his was a physicist, specifically, an astronomer and his father was a researcher. Instead of studying science as it is currently being taught, Dr. Bhattacharya stresses on the importance of experimenting with science. He says, “The vvvvwhole process of rote learning everything turns students away from pure science. To encourage them to pursue it, they need to be shown the exploratory aspect of science, the aspect that makes them think, and makes it enjoyable.”

What's in Chemistry Lab?

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Balance
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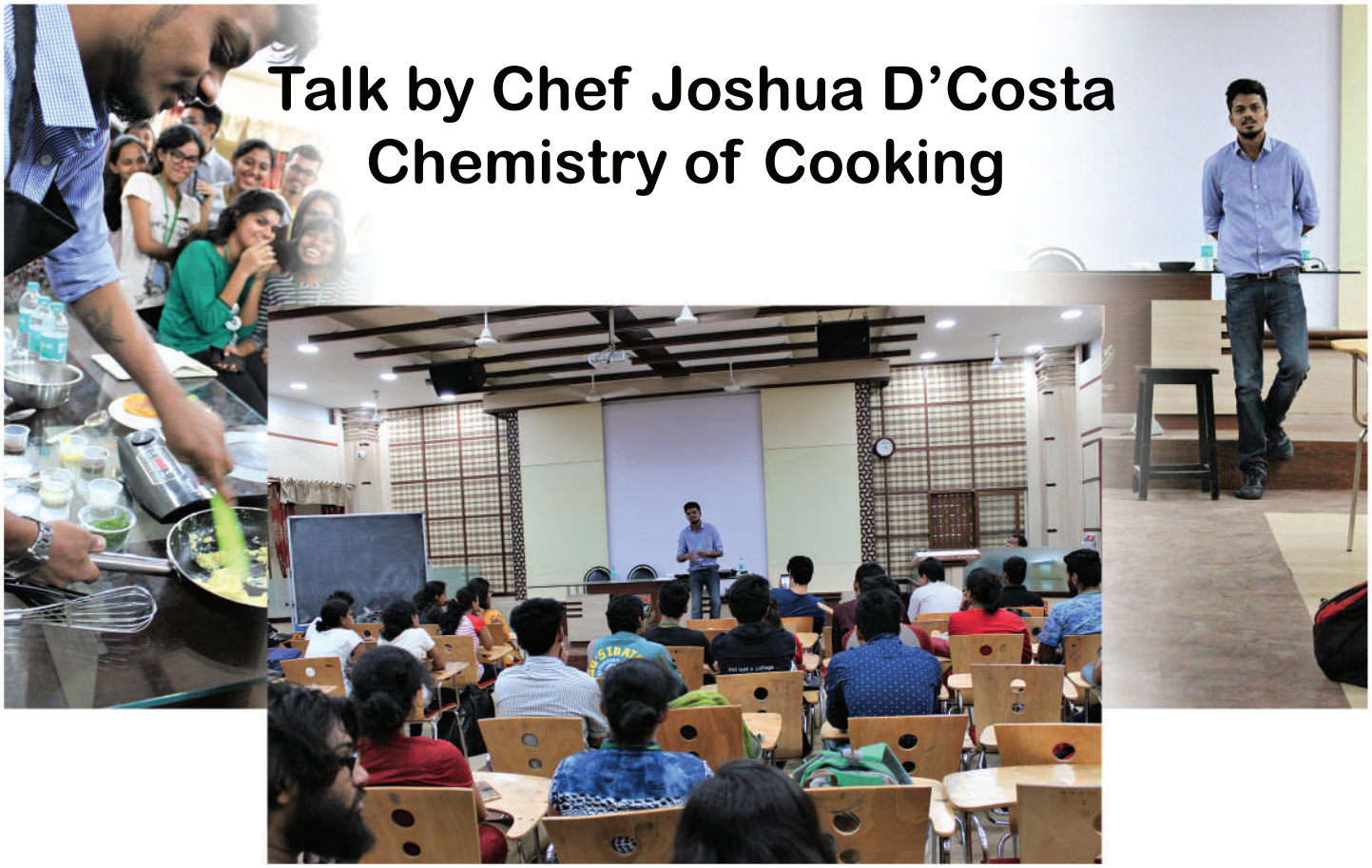
Burner
Condenser
Crucible
Filter Paper
Lithmus Paper
Pipette
Test Tube
Thermometer
Tongs
Volumetric Flask
Watch Glass
Wire Gauze

Talk by Chef Joshua D'Costa
Chemistry of Cooking



Good Lab Practices by Borosil

Matheran Trek by XAC

ALCHEMIA '18

Public Lectures & Events

Career Guidance talk - Dr. Vatsa

Molecular Machine talk
-Prof. Roop Malik

Student Talks

Chem Housie

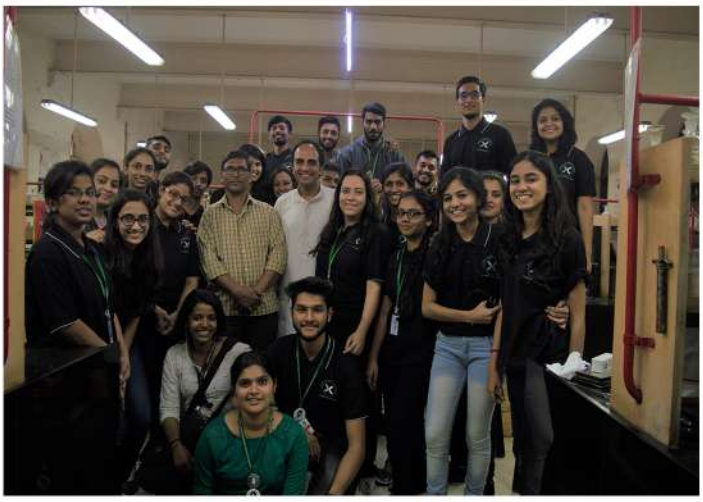
Quiz

Treasure Hunt

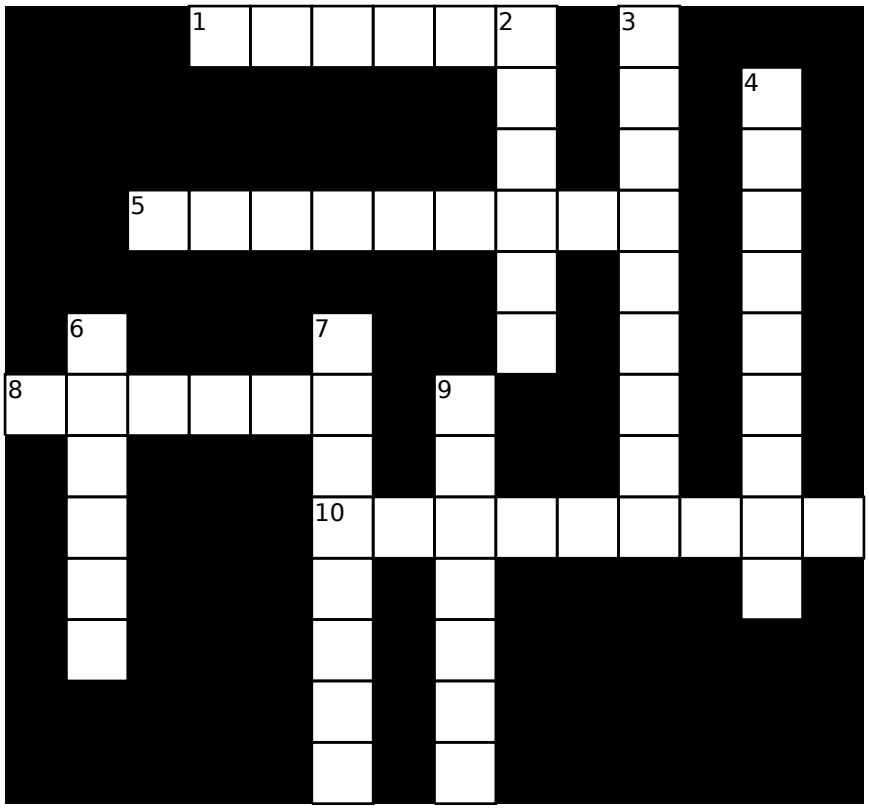
Events & Exhibition

Spell C

Alchemia ‘18
Professors & Workforce



The "Elemental" Crossword Puzzle



Across

1 The Metal with the Highest Electrical Conductivity.

5 Fourth Period Metalloid which is an Important Semiconductor Material.

8 A Common Element in Brass and Bronze

10 The Element used in the Manufacture of Headphones.

Down

2 The Element Discovered in 1989 by Pierre and Marie Curie.

3 The Metal whose Oxide occurs Naturally as Ruby or Sapphire.

4 The Nitrate Salt of This Element is the Main Ingredient in Gun Powder.

6 A Halogen used in Medicine

7 The Most Unstable of the First 101 Elements

9 Liquid Halogen at Room Temperature.

Love Not Actually?

-Lorraine Tellis
TYBSc

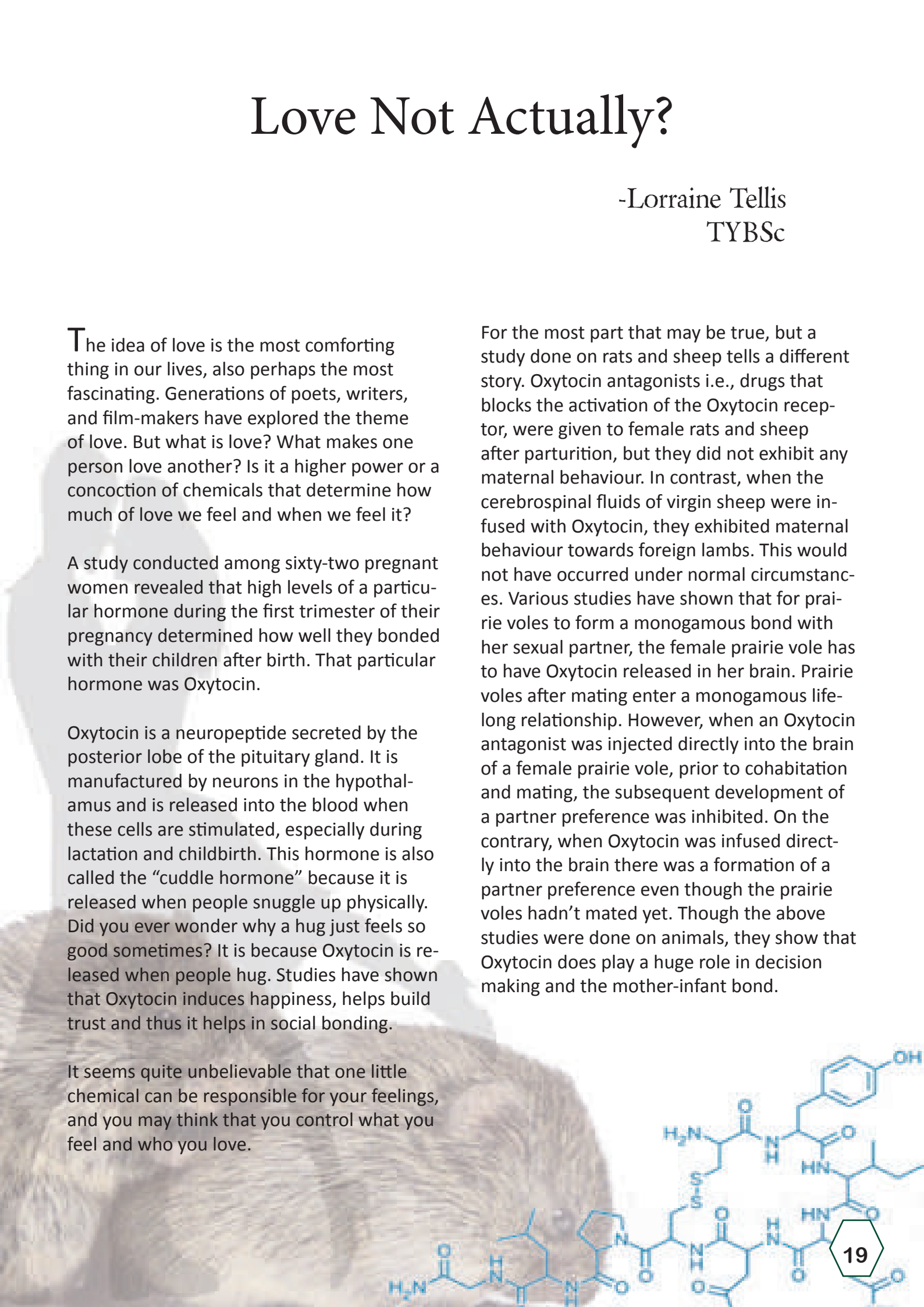
The idea of love is the most comforting thing in our lives, also perhaps the most fascinating. Generations of poets, writers, and film-makers have explored the theme of love. But what is love? What makes one person love another? Is it a higher power or a concoction of chemicals that determine how much of love we feel and when we feel it?

A study conducted among sixty-two pregnant women revealed that high levels of a particular hormone during the first trimester of their pregnancy determined how well they bonded with their children after birth. That particular hormone was Oxytocin.

Oxytocin is a neuropeptide secreted by the posterior lobe of the pituitary gland. It is manufactured by neurons in the hypothalamus and is released into the blood when these cells are stimulated, especially during lactation and childbirth. This hormone is also called the “cuddle hormone” because it is released when people snuggle up physically. Did you ever wonder why a hug just feels so good sometimes? It is because Oxytocin is released when people hug. Studies have shown that Oxytocin induces happiness, helps build trust and thus it helps in social bonding.

It seems quite unbelievable that one little chemical can be responsible for your feelings, and you may think that you control what you feel and who you love.

For the most part that may be true, but a study done on rats and sheep tells a different story. Oxytocin antagonists i.e., drugs that blocks the activation of the Oxytocin receptor, were given to female rats and sheep after parturition, but they did not exhibit any maternal behaviour. In contrast, when the cerebrospinal fluids of virgin sheep were infused with Oxytocin, they exhibited maternal behaviour towards foreign lambs. This would not have occurred under normal circumstances. Various studies have shown that for prairie voles to form a monogamous bond with her sexual partner, the female prairie vole has to have Oxytocin released in her brain. Prairie voles after mating enter a monogamous lifelong relationship. However, when an Oxytocin antagonist was injected directly into the brain of a female prairie vole, prior to cohabitation and mating, the subsequent development of a partner preference was inhibited. On the contrary, when Oxytocin was infused directly into the brain there was a formation of a partner preference even though the prairie voles hadn’t mated yet. Though the above studies were done on animals, they show that Oxytocin does play a huge role in decision making and the mother-infant bond.



A similar effect on decision making was seen in humans too. In a study, some fathers were given a nasal spray of Oxytocin. Those given the spray played with their toddlers more as compared to those who were given the placebo. Another group of researchers gave a group of men who were in relationships a nasal spray of Oxytocin and another group of men the placebo. They found that those who got the Oxytocin stood further away from an unknown attractive woman than the men who weren't given any Oxytocin. It was also found that there was no change in the behaviour of single men. Therefore, the Oxytocin helped strengthen the commitment bond between the men and their partners. These findings may also suggest that Oxytocin works as a fidelity booster for men who are already bonded with another woman. So, if you are ever worried about your other half's wandering eyes, some Oxytocin spray may actually help you.

This brings us back to our original question: Are we actually in charge of our feelings? Is it a 'Higher Power' or is it a dose of chemicals that controls whatever we feel? I guess we may never really know, but we can always choose to believe the option that suits us best!

Putting the 'Sci' in Sci-Fi

- Anish Ittoop
TYBSc

Science is a beautiful phenomenon. The boundaries of Science are pushed when explaining it in a universe where individuals break its fundamentals a regular basis. I am, of course, talking about science fiction (a genre of movie/TV shows that most of us appreciate). I shall explain a few of these amazing concepts and hopefully give you something to think about the next time you watch Sci-Fi.

How sharp is Wonder Woman's Sword?

This year gave us a lot of great new movies. One that I really enjoyed was 'Wonder Woman'. In it was showcased all of her Amazonian weapons, ranging from her 'Lasso of Truth' to 'The Sword of Athena'. But our focus will be on how amazing her sword actually is. In the comics, it is said that the sword is so sharp, it is capable of cutting "In between electrons". This is not a line to be taken lightly. Some of the sharpest blades of our day are made of Obsidian, possessing a sharp edge of just 3 nanometres. However, her Sword is quite literally 100 times sharper than the sharpest tool we have in existence today! Having said this, let's further get into what these specifications can allow. Lightning is caused due to ionization of the air, because of the massive electrical potential difference between the clouds and the surface of earth ripping the electrons from the gas molecules of air and resulting in the brilliant display. No such massive energy requirement is needed for Diana. A single swing of her sword is enough to rip the electrons from the gases in the air, ionizing them, and essentially generating lightning bolts with every slash. Think of that the next time you watch the movie!

Give this Man some Mouth Wash... The truth behind Godzilla's Atomic breath

As a child, I loved Dinosaurs. What happens when you cross a Dinosaur like creature with radiation? You get Godzilla and it was the most beautifully destructive thing a 5 year old boy wanted to see. I never wanted any monster trucks, I wanted a Godzilla! Alas, I didn't realise the true ramifications of such a pet. Godzilla's famous "Atomic breath" is a stream of what appears to be blue flames from its mouth. The explanation for this was that Godzilla generates a nuclear explosion within itself and directs the energy from that to generate its

Atomic breath. This is what raises a lot of questions. 70-95% of the energy in a nuclear explosion is lost in the form of a shockwave and heat. By this logic, the atomic breath should show results similar to that of a nuclear explosion, but it doesn't. The mighty Kaiju draws out his signature attack from the other 5% of the explosion, from within itself This energy is in the form of radiation. The blue hue to its breath is due to the ionisation of gases in its path. The ionizing radiation (Gamma, Beta and Alpha) are what forms this mighty beasts attack. This form is not as destructive, but is much scarier. Spewing enough ionizing radiation to turn the air blue is enough to transmute the particles in the ground, making them radioactive, making any place Godzilla thrashes through uninhabitable for upto thousands of years. This is much worse than just a few building being blown up.

XenoMorpghology and Anatomy

Xenomorphs from the 'Aliens' movie line is something that gave me chills as a child and they continue to do so even today. What can only be classified as weaponised biology, xenomorphs are quite literally designed to destroy. But what about their blood? In the movie there is a scene in which while inspecting the xenomorph's body, an accidental incision spurts out some of the xenomorph's blood, which then proceeds to eat through 3 levels of the spaceship in a matter of seconds. Another similar feat is seen in season one of the TV show, 'Breaking Bad', where hydrofluoric acid proceeds to eat through not only the ceramic bathtub but also the floor beneath it (along with the corpse of the unfortunate dealer too, that is). However, this took a significant amount of time and would not be a plausible explanation for the xenomorphs blood. The blood from the movies is in fact, far worse. The closest corrosive prowess we see with our current scientific ability is that of Fluroantimonic Acid. This acid, formed by the unholy unity of Antimony fluoride and Hydroflouric acid is capable of replicating similar results as that of the scene in the Movie. It eats through everything except for the specifically generated synthetics that are used to store it. Possessing a pH reading of a staggering -31.3, it is far from what we would consider "Ideal circulatory fluid". Looks like the Xenomorphs' keto diet lead to acidosis that went just a little out of control.

A Bacterial Revolt against an Antibiotic Assault

-Surendra Surwade
TYBA

With the discovery of Penicillin – the first ever antibiotic, by Alexander Fleming in 1928, the bacterial spread of infections and diseases started experiencing a revolutionary downfall. Bacteria, organisms that existed on Earth centuries before the humans came into existence, seem to have evolved much like human beings in their structure and behaviour. The human race observed a significant positive impact of antibiotics against pathogenic and environmental bacteria. However, in recent decades, scientists have identified a tremendous increase in antibiotic resistant bacterial species. This is sometimes also referred to as Antibiotic Apocalypse. An ongoing microscopic war, between the antibiotics and the bacteria is in its most crucial phase today. Scientists, health analysts, medical officers, doctors, hospitals and governments all over the world have come to realise the potential threat of this phenomenon to human life. Before focussing on the consequences and solutions of the given concept, let us concentrate on what has caused the occurrence of this antimicrobial resistance.

These causes could be seen at two different interlinked levels of interactions. First, the cellular level which helps us understand how exactly are the bacteria becoming resistant to the antibiotics. Second, human interactions and activities that promote the given resistance.

At the Microscopic level

Antibiotics act on bacterial cells majorly by attacking the cell wall or by disrupting its protein synthesis. When an antibiotic is of the type that targets the peptidoglycan (in the cell wall), it disturbs cell division causing the cell to rupture.

In case of an antibiotic that is meant to hamper protein synthesis, it binds to the ribosome inside the bacterial cell and halts the growth process. Now the question arises, how do bacteria become resistant to these actions of the antibiotics.

Natural Selection (Charles Darwin, 1835) serves as a basic premise for the evolution of the bacterial species to fight against antibiotics. Taking this argument forward, over the years bacteria (much like us), have evolved in various ways adapting to certain factors that hamper their growth. Some bacteria have a less permeable peptidoglycan, thereby prohibiting entry of the antibiotic into cell. Others have undergone major mutation, enabling them to create enzymes which destroy the antibiotics even before they can affect it. The other mode of resistance is a pump system to throw the entered antibiotics out of the cell.

In 2011, Squire Booker an associate professor in the Department of Chemistry at Penn State University, Pennsylvania, along with this team discovered a crucial chemical mechanism that explains how antibiotic resistance develops in certain species of bacteria. They discovered that non-human pathogenic bacteria Staphylococcus sciuri evolved a new gene called cfr protein. This gene, due its mobile DNA was easily transferred to human pathogen Staphylococcus aureus. For antibiotics hampering protein synthesis, this gene creates an obstacle. It methylates (adds a molecular tag) to the ribosome at a location different from the cell's original

molecular tag, preventing the antibiotic from affecting the ribosome.

Human interactions and activities promoting Superbugs

Today, when a person travels to a foreign land, stays there for a while and revisits his/her home country, he/she is at the potential risk of carrying the bacterial species present abroad to the home land. The major sources of these pathogens being food, water and air. This flow of human beings across the world, within their own country/state for whatever reasons have led to the simultaneous flow of various types of bacteria across the globe. Not to mention, these interactions spread multi-resistant genes among the microbes thereby making them resistant towards not just one but various types of antibiotics.

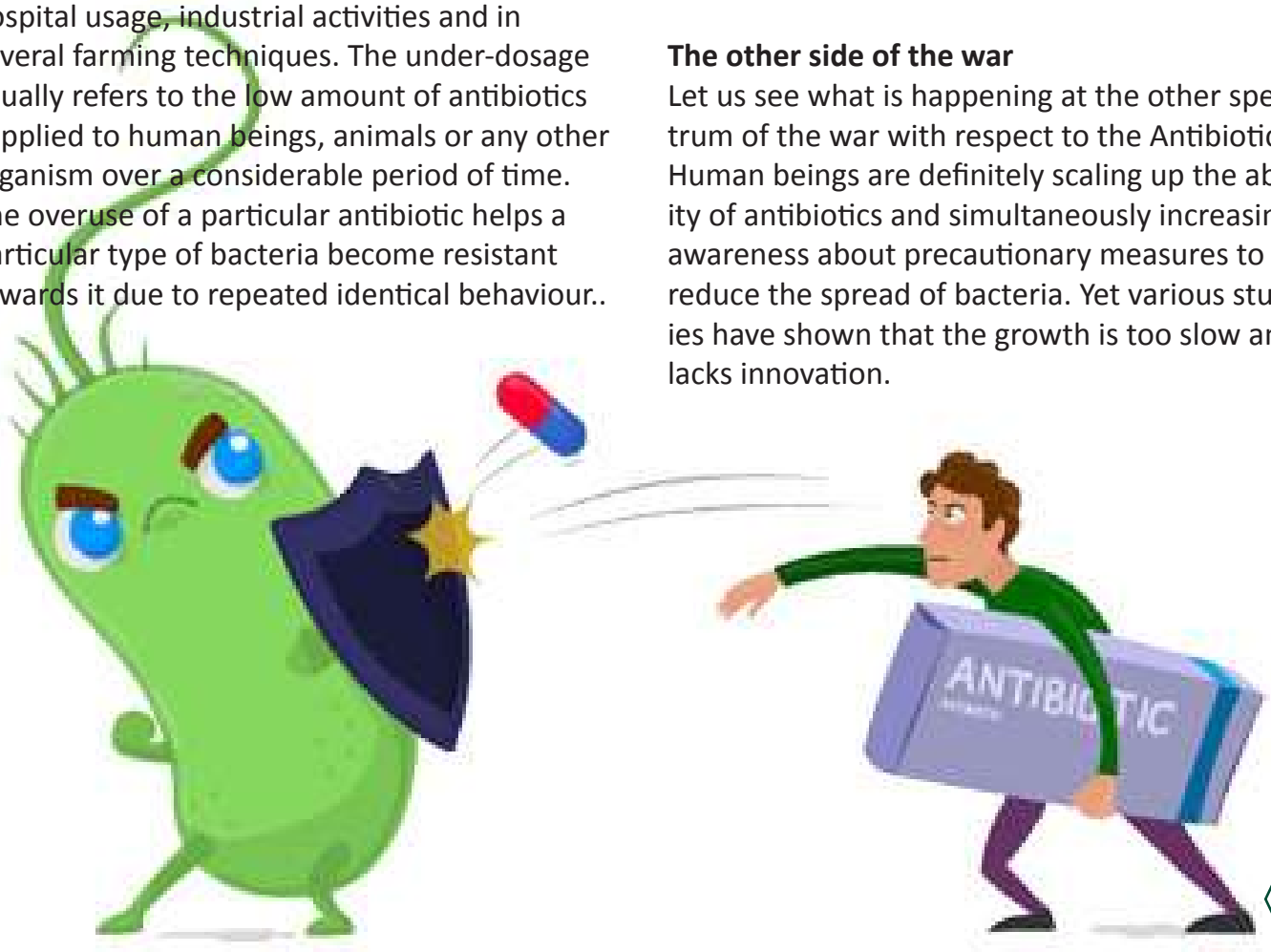
The overuse and under-dosage of antibiotics is what fuels the power of the bacterial resistance. These two concepts might seem paradoxical in their meaning but they are actually not. The overuse of antibiotics refers to the unnecessary, increased usage of the drugs by human beings for personal health concerns, hospital usage, industrial activities and in several farming techniques. The under-dosage usually refers to the low amount of antibiotics supplied to human beings, animals or any other organism over a considerable period of time. The overuse of a particular antibiotic helps a particular type of bacteria become resistant towards it due to repeated identical behaviour..

The antibiotic resistant bacterial species, often referred to as superbugs transfer their resistant genes to other bacteria via reproduction or conjugation (by direct cell-to-cell contact). The under-dosage of an antibiotic into a living body is equivalent of preparing the bacteria for resisting larger doses. The low, insufficient amount of the drug is incapable of killing the bacterial cells and is counterproductive to the purpose of antibiotics. In fact, Alexander Fleming in 1945, while delivering his Nobel Prize speech gave a warning about the under-dosage of penicillin in the future. In his words, “The time may come when penicillin can be bought by anyone in the shops. Then there is the danger that the ignorant man may easily under-dose himself and by exposing his microbes to non-lethal quantities of the drug make them resistant.” The present times quite accurately mirror Fleming’s vision.

From this we can conclude how the bacteria have strengthened their position in this widespread, nano-sized war. This leads us to the question of knowing whether the antibiotics are also progressing to catch up with their rivals or not. If so, how?

The other side of the war

Let us see what is happening at the other spectrum of the war with respect to the Antibiotics. Human beings are definitely scaling up the ability of antibiotics and simultaneously increasing awareness about precautionary measures to reduce the spread of bacteria. Yet various studies have shown that the growth is too slow and lacks innovation.



Since the first antibiotic was discovered, only 4-5 major types of antibiotics have been newly found. No new type of antibiotic has been developed in the last 30 years. Figure 1 gives a rough timeline of the same.

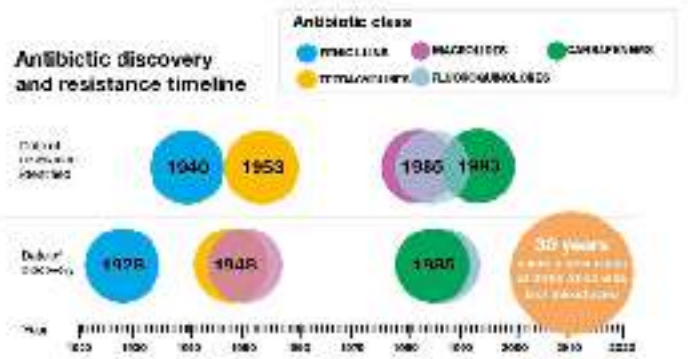


Fig1

As for the existing types of antibiotics, majority of them have found their corresponding resistant genes, thereby increasing concerns at an alarming rate. In a recent study at Delhi's Ganga Ram Hospital, Klebsiella pneumoniae showed increased resistance from 2% to 52% against the most effective antibiotics – carbapenems. Doctors use these antibiotics as the last resort when all other categories fail to work.

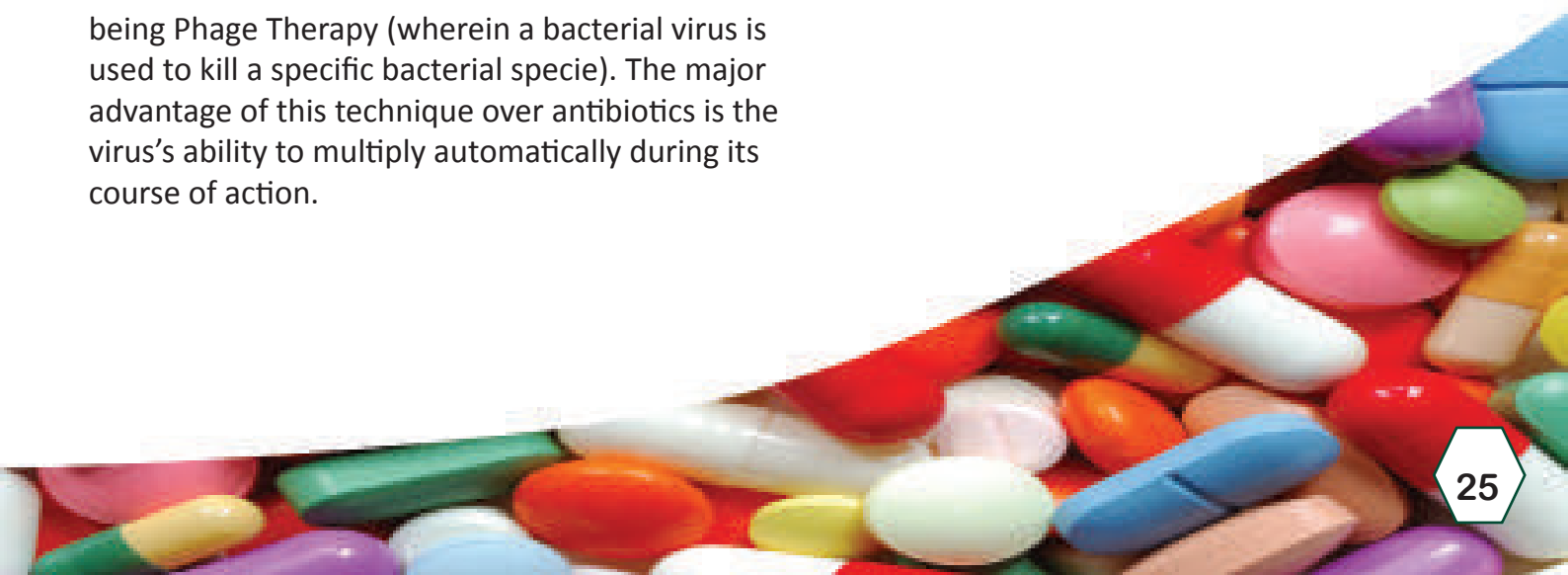
By now it is established that the bacteria have the ability of becoming resistant to any kind of antibiotic. We cannot bring this Bacterial Revolt to a halt. This hasn't discouraged research in the field since there's always scope for the new antibiotics to work for a considerable amount of time until the corresponding superbugs emerge. Yet various scientists are pro-innovation, aiming to find other alternatives. The other close alternative being Phage Therapy (wherein a bacterial virus is used to kill a specific bacterial specie). The major advantage of this technique over antibiotics is the virus's ability to multiply automatically during its course of action.

On killing a bacterium, the virus multiplies into several other identical viruses and further enhances the antibacterial activity. This process of Auto-dosing counters the problem of antibiotic under-dosage. Most of the existing mechanisms aim at directly killing the bacterial cells, research is slowly discovering ways to alter bacterial signals and resistant activities instead of directly killing the cells.

The Real war

If we carefully observe, the real fight is between the Human beings and the superbugs. The antibiotics are just a weapon from the human race which is slowly failing to tackle the infectious, pathogenic bacteria. Tomorrow when phage therapy may become prominent, bacteria would evolve in a way that they become resistant to viruses too. While at one hand it is necessary to ensure the end of such microbes, it's equally wise and important to find ways to curb their initial spread. The International Food Standards do not ask to check limits of antibiotic resistant bacteria in the food products imported/exported, government action plans lack focus on Antimicrobial resistance. The Ganges – the 'purest' river of our country- continues to be an ensemble of various kinds of superbugs. Hence, there is a need for the preventive measures to run parallel to the curative measures.

With the advent of new technology, increased widespread awareness among the people and successful implementation of the new methods, the human race could definitely succeed in turning this war into peace.



Moving Scales: From Macro to Micro

- Vivek Neilaj,
TYBSc

Have you ever thought, what is this universe made up of?
5% normal matter, 25% dark matter, 70% dark energy, we've just got a bit of stuff.
Normal matter consisting of atoms, humans, planets and stars,
With every visible object that the universe has in its bars.
Using thousands of brains and with huge amount of practice,
Scientists came to a conclusion that this dark energy doesn't even exist.

Have you ever thought, in which galaxy do we stay?
It has a spiral kind of structure, and its name, 'The Milky Way".
As we are part of the universe with the other planets and their charm,
Our sun also orbits the galaxy, and is located near the outward tip of its Sagittarius arm.
This solar system has its own galactic year, one that never freezes,
And also the suspicion that our Milky Way is absorbing smaller galaxies.

Have you ever thought of how Earth was actually formed, for real?
It was a collision, between the Earth and an embryonic planet named Theia.
The collision was big, enough to give birth to a moon,
Which came out as a chunk and was caught in the Earth's gravity soon.
The moon has had its own ratio of oxygen isotopes, ever since its birth,
And so it clearly shows, and we now know why we call her "Mother Earth".

Have you ever thought, who was the first human to live?
It was found by a student in the ledi-Geraru research area, which was hard to believe.
A fossil of a 2.8-million-year old lower jawbone and was named ledi-jaw,
It made a link between an iconic 3.2-million-year old Hominin named Lucy, as it was raw...
This discovery pushed the human line back 400,000 years, closer to its pre-human ancestor,
And indicates that it may well have been the evolutionary descendant by a greater factor.

Have you ever thought, which is the smallest living organism?
It is a parasitic bacterium called Mycoplasma genitalium.
It lives in the primitive bladder, waste disposal organs and respiratory tracts,
With a size of 200nm, having independent growth and reproductive sacks.
M. genitalium is smaller than Rickettsia and Shigella,
And that is why, it is classified under ultramicrobacteria.

JUMBLE

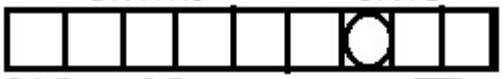
Rearrange the jumbled letters to create words and fill in the blocks.
Rearrange the letters in the circles to solve the clue at the end.

1. GEOCHEMISTRY

MAEILNSR

LIREHHESOPT

AMHEETAIT



CRUDUNOMR

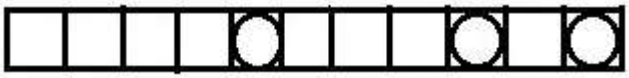
Clue: The element that confirmed the extinction of dinosaurs by an asteroid impact. The evidence was given by a Professor at UC Berkeley who later on published a book regarding the same.

2. NUCLEAR CHEMISTRY

INAGIGM

OPQEAU

YOORFSCOLPU



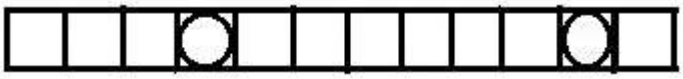
NDUCIOLE

Clue: Studying X-Rays and their use for medical imaging is called _____.

3. COSMOCHEMISTRY

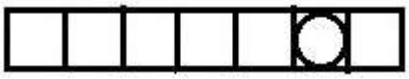
MOERETTIE

INLRASETLTER



STUD

IOOSPET



Clue: A moon which is sixth closest to its respective planet, mostly made up of silicate rocks. It is one of the objects in our Solar System that has a high probability of harbouring life.

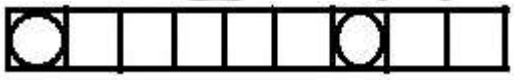
4. POLYMER CHEMISTRY

GIATNOLE

CSKORILNSS

ELSTERMOA

BRHNICNAG



Clue: A thermosetting polymer formed from a condensation reaction of phenol with formaldehyde.

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3. Moving Scales

- https://www.universetoday.com/74464/what galaxy do we live in/
- First human discovered in Ethiopia-BBC news, Science and environment

ARTWORK:

Moving Scales: Vivek Neilaj, TYBSc.

Crossword: Manica Argrawal, FYBSc.

Jumble: Pradyumna Srivastav, FYBSc.

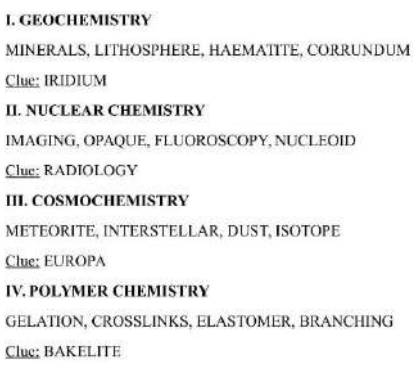
Word Search: Abhishek Soni, FYBSc.

SOLUTIONS TO PUZZLES:

Crossword

Word Search

Jumble words



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