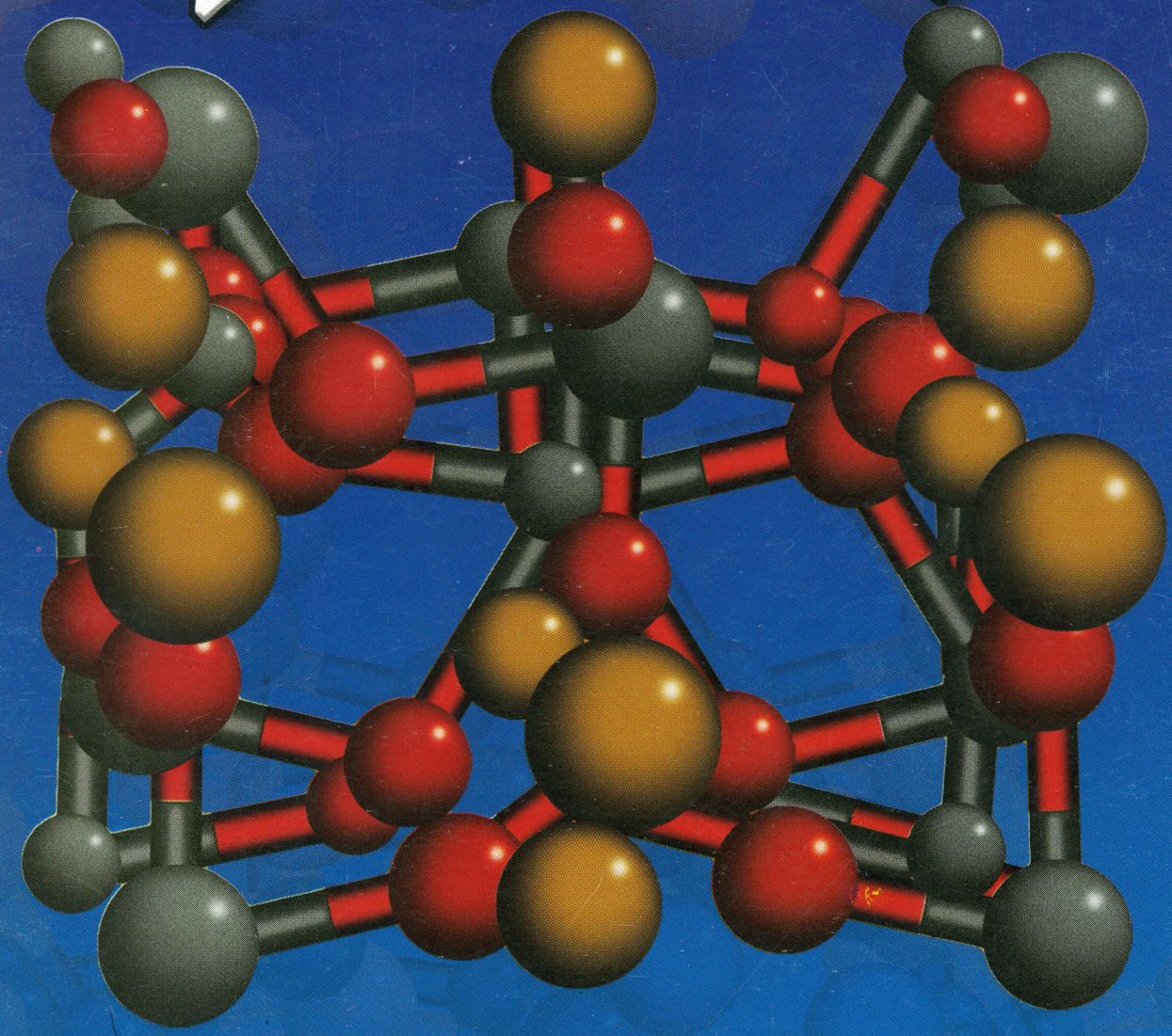
ZIRCON



DEPARTMENT OF CHEMISTRY
STELLA MARIS COLLEGE
2003 - 2004

EDITORIAL BOARD

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HARINI SUBRAMANIAN - II B.Sc.,

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FOREWORD

The influence of Chemistry on society has been extensive and this has caused generations of people to study this subject in depth, which is as old as science itself, to delve more and more into its recesses. Nobody knows when it all began but what we know today is that in this microcosmic world Chemistry plays a major role - chemistry between plants and animals and even more between human beings. To broaden our horizons, expand our vision and to think beyond fashionable rhetoric is the aim of this journal, which is being published on the 40th anniversary of the founding of the Department of Chemistry at Stella Maris College.

It is imperative that scientific knowledge is shared especially with the younger generation and what better way than to kindle their interest in science through books and magazines? Toby Fulwiler, editor of 'The Journal Book' states the idea behind journals, logs, notebooks, or field notebooks: "When people write about something they learn it better". Journals, he adds, give students "a place in which to write informally yet systematically in order to seek, discover, speculate and figure things out". This publication will carry forward the efforts and achievements of the Department.

I congratulate my colleagues and the students in the department on this venture and look forward to this magazine, which will stimulate more ideas and enhance the performance of the department.

Dr. Sr. ANNAMMA PHILIP, fmm
Principal and Head,
Department of Chemistry

What's In Store...

FROM THE EDITORS' DESK

"Why not bring out a department magazine?" came a suggestion. A lot of eyebrows went up simultaneously and we gave each other absolutely skeptical looks. What? We? Bring out a magazine? Edit articles? But, that's improbable! Well, here we are! If it had not been for the support of our faculty and the enthusiasm that was shown by the entire department, the whole idea would have collapsed like a house of cards and would have just remained a dream. Yes, the journey was fraught with hardships and called for a lot of hard work, but amidst such bubbling spirit we never felt the strain and had no need to complain.

We were taken by surprise at the zealous response to our call for contributions. Everybody put on their thinking caps and was ready to offer their creative best to this venture. There was an inflow covering a wide spectrum of issues with respect to chemistry at large. It was a Herculean task picking out a handful of articles from the entire pile! The process of compiling and editing was a whole new experience. It was a perfect blend of learning and fun.

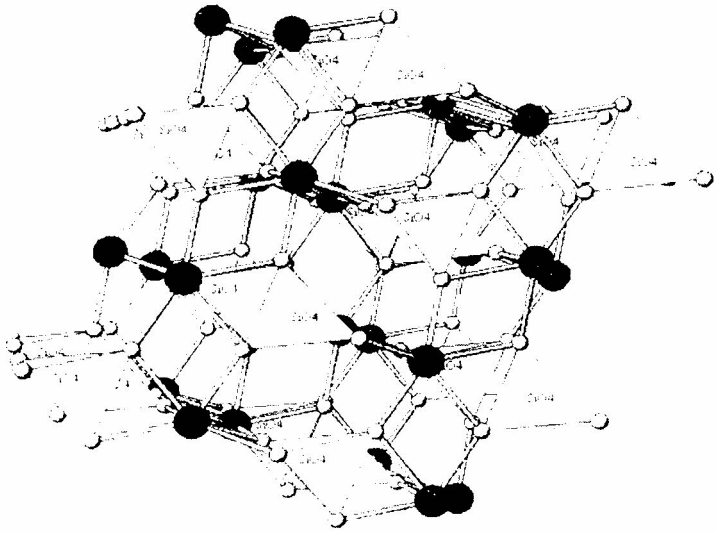
The dream begins with a teacher who believes in you, who tugs and pushes and leads you to the next plateau, sometimes poking you with a sharp stick called "truth."

-Dan Rather

To this noble profession of teaching, we dedicate this magazine "Zircon".

THE EDITORIAL BOARD

FORTY AND GOING STRONG!!



Hey guys! I am Zircon, the stone of luck. The Arabs call me Siriqin, which means vermilion, and the Persians refer to me as Azargun (golden hued). I am the December birthstone. I am a multi-faceted personality and come in vibrant shades of blue, brown, red, yellow, green and black. Sometimes I choose to lay low and be colourless. But my fire and brilliance can rival that of any other gemstone..... Hey, wait a minute, why are we speaking about Zircon in the first place?

The Department of Chemistry, Stella Maris, has completed 40 years of service and hence this magazine, dedicated to this cause, has been aptly named Zircon. (Incidentally, the atomic number of zirconium is 40).

Ok, where was I now? My cousin, the brown zircon, on heat treatment can produce nearly any colour of the rainbow. I give out colour owing to colour centres and trace quantities of iron. I generally don't reveal this to anybody but in your case I'll make an exception: I am 4.4 billion years old, making me the world's oldest known terrestrial material! I generally prefer the company of some close friends like U, Th and Pb.

So, I sound interesting, huh? I hope that with me as their mascot, the Department of Chemistry continues to illuminate the young minds of scores of generations to come.

- R. SHARANYA I B.Sc

DAZZLING GEMS

Gems are all chemicals existing as elements (diamond), or compounds (oxides or silicates) or mixture (garnet family is a mixture of iron, magnesium, aluminium or calcium silicates). Gems are formed as crystals when the earth's crust cools over millennia- larger crystals in areas of slow cooling of molten rock, and smaller crystals in areas of rapid cooling. Gems may be formed in single or multiple discrete crystals (diamond) or massive collections of microscopic crystals (crypto-crystalline chalcedony) or amorphous masses (opal).

REASON FOR DAZZLE:

Colour is the apparent result of selective absorption or transmission of different frequencies of visible light and can be described as the combination of three characteristics: hue, tone and intensity. Hue is a function of the frequency of light and is described by "VIBGYOR"; tone is a variation from pale to dark shade; intensity is a measure of saturation or purity of a colour. The "d" electrons of transition metals absorb visible radiation, generating electronic transitions between energy levels. The colour of the mineral corresponds to the wavelength of the unabsorbed visible radiations and depends on the metal ion, the level of its oxidation state affecting the intensity.

BIBLICAL REFERENCE TO GEMS:

"And the building of the wall of it was of jasper: and the city was pure gold, like unto clear glass, and the foundations of the wall of the city were garnished with all manner of precious stones.

The first foundation was jasper; the second, sapphire; the third, chalcedony; the fourth, an emerald; the fifth, sadonyx; the sixth, sardius; the seventh, chrysolyte; the eigth, beryl; the ninth, a topaz; the tenth, a chrysoprasus; the eleventh, a jacinth; the twelfth, an amethyst."

Revelation 21:18-20

Here is an excerpt from Ezekiel's lamentation upon the King of Tyrus.
"You were in Eden the garden of God; every precious stone was thy covering,
the sardius, topaz and the diamond,
the beryl, the onyx and the jasper,
the sapphire, the emerald and the carbuncle and gold:
the workmanship of your tumbrels and pipes was prepared on the day you were created."

Ezekiel 28:13

BIRTHSTONES:

MONTH	MINERAL NAME	COMPOSITIONAL FORMULA	CRYSTAL SYSTEM	COLOUR
January	Garnet (almandine)	$Fe_3Al_2(SiO_4)_3$	Cubic	Deep transparent Red
February	Amethyst	Containing a small amount of Fe ion in SiO_2	Hexagonal	Purple, Violet
March	Aquamarine	$Be_3Al_2Si_6O_{18}$	Hexagonal	Bluish Green
April	Diamond	C	Cubic	Colourless
May	Emerald	$Be_3Al_2Si_6O_8$	Hexagonal	Bright Green
June	Moonstone	$(K,Na)AlSi_3O_8$	Triclinic	Colourless
July	Ruby	Containing a small amount of Cr in alfa-Al_2O_3	Hexagonal	Deep Red
August	Peridot(olivine)	$(Mg,Fe)_2SiO_4$	Rhombohedral	Yellowish Green
September	Sapphire	Containing a small amount of titanium or iron in alfa-Al_2O_3	Hexagonal	Clear bright Blue
October	Opal	Amorphous which added water to SiO_2	Amorphous	Bluish White, milky White
November	Topaz	$Al_2SiO_4(F,OH)_2$	Rhombohedral	Colourless, Caramel, Yellow, Pink
December	Turquoise	$CuAl_6(PO_4)_4(OH)_8$	Triclinic	Greenish Blue

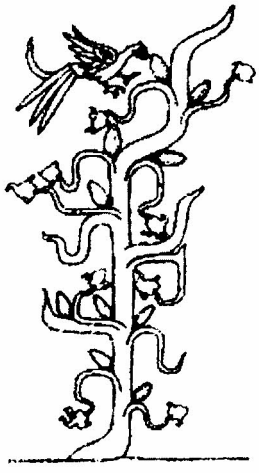
- KAREN SAMUEL I B.Sc
- K LAVANYA I B.Sc
Ms. MARY GEORGE
Faculty, Dept. of Chemistry

WISE CRACK!

A physicist, biologist and chemist went to the ocean for the first time. The physicist saw the ocean and was fascinated by the waves. He said he wanted to do some research on the fluid dynamics of the waves and walked into the ocean. Obviously he was drowned and never returned. The biologist said he wanted to do research on the flora and fauna inside the ocean and walked into the ocean. He too never returned. The chemist waited for a long time and afterwards recorded his observation. "The physicist and biologist are soluble in ocean water"!!!

SWEET TOOTH

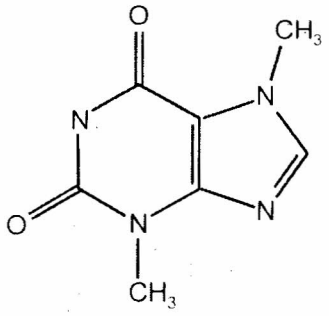
A bar of chocolate is worth a million smiles! Have you ever wondered what makes chocolates so special (apart from the fact that they are delicious)? There are few foods that people feel as passionate about - a passion that goes beyond a love for the "sweetness" of most candies or desserts. For the true chocoholic, just thinking about chocolate can evoke a pleasurable response. Chocolates have been leaving their mark on mankind for a long time now; almost eons. Sounds improbable? Here are the facts.



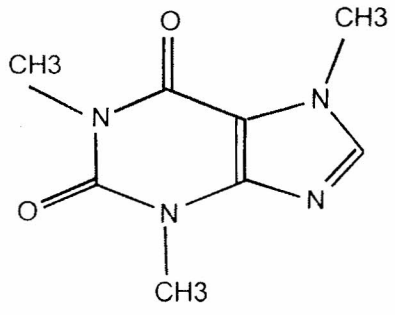
Cacao tree detail from a ninth century Mayan mural at Cacaxtla, Mexico.

By the beginning of the 16th century, the Aztecs had an advanced and powerful civilization in what is now central Mexico. Many people believe that the Aztecs first developed chocolate. However, chocolate goes back much farther. The ancient Maya, who inhabited what is a now part of southern Mexico and Central America, certainly consumed chocolate. In fact, the word "cacao" is Mayan; as early as 500 A.D., the Maya were writing about cacao on their pottery. Some think chocolate may be even older, dating back to the Olmec civilization that preceded the Mayan.

One of the most pleasant effects of eating chocolate is the "good feeling". Chocolate contains more than 300 known chemicals. **Caffeine** is the most well known of these chemical ingredients though it is found in small quantities. **Theobromine**, a weak stimulant, is also present, in slightly higher amounts. The combination of these two chemicals (and possibly others) may provide the "lift" that chocolate eating provides.



THEOBROMINE



CAFFEINE

Theobromine belongs to a class of **alkaloids** known as **methylxanthines**. **Drewnowski** found that eating chocolate causes the brain to produce natural opiates, which dull pain and enhance the feeling of well-being. If the receptors in the brain that signal the presence of opioids were blocked, there would be no chocolate bingeing. It was not shown, however, if this was caused by the high fat or sugar content of chocolate candy.

Chocolate also contains **phenylethylamine**, a chemical related to amphetamines. Like amphetamines, this raises blood pressure and blood sugar levels, resulting in a feeling of alertness and contentment. Caffeine in chocolate may also cause feelings of alertness and a pounding heart. Other stimulants in chocolate include theobromine and methylxanthines. These caffeine-relatives are weaker than caffeine-you would have to eat more than 12 bars of chocolate to get as much caffeine as there is in one cup of coffee. All of these stimulants increase the activity of neurotransmitters in the brain.

However the same wonderful elixir is lethal to dogs and horses. But that is another story altogether.

CHOCOLATE: FRIEND OR FOE?

Myth : Like red wine, dark chocolate is supposed to be good for your heart.

Fact : Like red wine, dark chocolate contains a substantial proportion of flavinoids and phenolics, possibly good for you heart.

Myth : Chocolate is one of dentists' worst enemies because of its effect on your teeth and gums.

Fact : This is due to the sugar in chocolate; regular brushing should counteract any problems caused!

Fact : There are indications that the cocoa butter in the chocolate coats the teeth and may help protect them by preventing plaque from forming.

Myth : Chocolate is thought to cause pimples or acne.

Fact : There is no hard fact to substantiate this.

Fact : Research shows that acne is not primarily linked to diet.

Myth : Chocolate eaters should be particularly careful in how they meddle with romances and chocolate!

Fact : Scientists have observed the aphrodisiac properties of chocolate.

- **BHARATHI RAMASUBBAN** (III B.Sc)
- **NEHA KUKREJA** (III B.Sc)
- **KAAVYA KRISHNA KUMAR** (II B.Sc)
- **HARINI SUBRAMANIAN** (II B.Sc)

FISCHER & FISCHER

"The German chemist Emil Fischer worked on important tissue compounds, the sugars and purines, and was awarded a Nobel Prize in 1902 for that work. Despondent over Germany's defeat in World War I (and over the loss of two of his three sons and his own ill health), he killed himself shortly after the war's conclusion. A young assistant of his was Hans Fischer - no relation - who also worked on important tissue compounds, the porphyrins, and was awarded a Nobel Prize in 1930 for that work. Despondent over Germany's defeat in World War II (and over the destruction of his laboratory by air raids), he also killed himself shortly after the war's conclusion.

"LET THERE BE LIGHT!" AND THERE WAS LIGHT

Who would have thought the old man to have had so much blood in him?

- Lady Macbeth

May 4, 1947. Normandy. Monsieur Ardenne was found lying dead in his apartment. Nothing was reported missing and the weapon resulting in death was not found. There were no signs of struggle and there were no clues to indicate a murder. One week later, one of his most prized paintings, "The Longest Day", was found to be a fake.

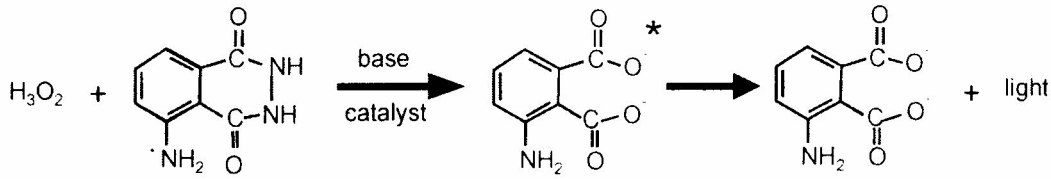
One month after the death of Monsieur Ardenne, the local museum curator was arrested on charges of simulating the murder. A heavy transaction had taken place in his bank account. His accomplice who had actually committed the murder was also traced. How do you think they solved the case?

Criminalistics is based on the notion that nothing vanishes without a trace. Tiny particles of blood will cling to most surfaces for years and years without anybody even realizing it. The place where the body was found was not the actual site of the crime at all, as the blood was not proportional to the size of the wound. When the investigators checked the area near the painting (obviously the motive of this murder), they found traces of blood, enough to indicate a struggle. Clearly, the body had been dragged to a different place after the murder was committed and the site of crime had been cleaned. They also found evidence of blood having been wiped off hastily from frame of the original painting, found with the curator. However, these traces weren't small enough to ward off luminol. This is where the ingenious intervention of chemistry comes in.

Luminol is a chemical that glows greenish blue when it comes into contact even with traces of blood, years old. Even if there is one drop of blood in 9,99,999 drops of water, luminol will glow. This happens because of a light producing chemical reaction between several chemicals and haemoglobin. The molecules break down and the atoms rearrange. In this particular reaction, the reactants have more energy than the products. The molecules get rid of the extra energy in the form of visible light photons. This process is known as chemiluminescence.

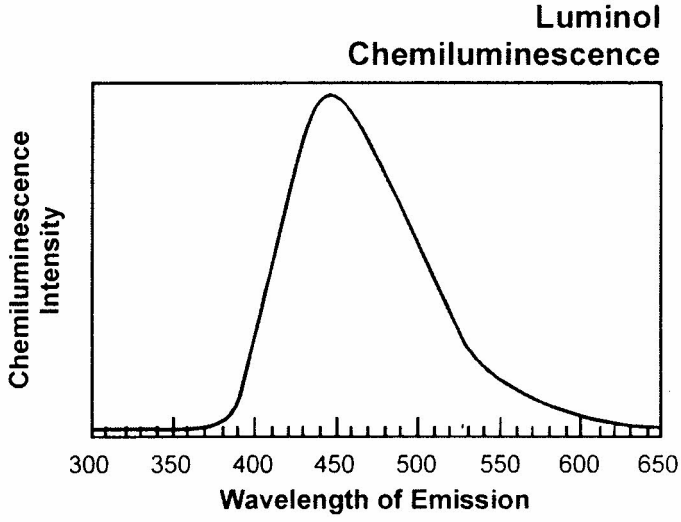
The chemiluminescent emitter is a "direct descendent" of the oxidation of luminol (or an isomer like isoluminol) by an oxidant in basic aqueous solution. Probably the most useful oxidant is also hydrogen peroxide similar to peroxyoxalate chemiluminescence; however, other oxidants such as perborate, permanganate, hypochlorite and iodine, have been used. The central

chemical in this reaction is luminol($C_8H_7O_3N_3$), a powdery compound. This is mixed with a solution of hydrogen peroxide (H_2O_2). Hydrogen peroxide and luminol are the principal players in the chemical reaction. But in order to produce a strong glow, they need a catalyst to accelerate the process. In this case, it is the iron in haemoglobin.



Hydrogen peroxide luminol 3-aminophthalate

The intermediate, 3-aminophthalate, is in an energised state. The electrons in the oxygen atom are boosted to higher orbitals. They quickly fall back to a lower orbital level, emitting energy as light. Luminol also reacts with some metals, paints, cleaning products and plant matter. However, the chemical's reaction to each differs in intensity. Metals, for example, cause an immediate glow that quickly fades, while blood glows longer.



Fantastic isn't it? In the words of Hercule Poirot, "every murderer has his undoing" and in this case it happened to be Luminol!

- HARINI SUBRAMANIAN II B.Sc

The red colour of blood and the green colour of plants are due to haemoglobin and chlorophyll respectively. They differ only in their metallic core i.e., Fe^{2+}in haemoglobin and Mg^{2+}in chlorophyll. There are creatures, which even have blue blood like some species of molluscs. The haemoglobin of their blood contains Cu^{2+} instead of Fe^{2+}.

THE KILLER LAKE- NYOS

Disaster struck swiftly and without warning on August 21, 1986. Lake Nyos in Cameroon, a small nation on the west coast of Africa, suddenly belched a dense cloud of carbon dioxide. Speeding rapidly down a river valley, the cloud asphyxiated over 1700 people. How did this tragedy happen?

Lake Nyos is inside the crater of one of the maars that was formed about 400 years ago. It is stratified into layers that do not mix. A boundary separates the fresh water at the surface from the deeper denser solution containing dissolved minerals and gases, including CO_2. The CO_2 gas comes from springs of carbonated groundwater that percolate upward into the bottom of the lake. Given the high water pressure at the bottom of the lake, the concentration of CO_2 gradually accumulates to a dangerously high level (Henry's Law).

What triggered the release of CO_2 is not known for certain. It is believed that an earthquake, a landslide or even strong winds may have upset the delicate balance within the lake, thus creating waves that upset the water layers. When the deep water rose, the dissolved CO_2 gushed out of solution, just as soft-drink fizzes when the bottle is agitated and uncapped. Being heavier than air, the CO_2 travelled close to the ground and literally smothered an entire village 15 miles away.

Now more than 15 years after the incident, scientists are concerned that the CO_2 concentration at the bottom of the lake is again reaching saturation. To prevent recurrence of the tragedy, an attempt has been made to pump up the deep water, thus releasing the dissolved CO_2. In addition to being costly this approach is controversial because the waters near the bottom of the lake could get disturbed, leading to an uncontrollable release of CO_2 to the surface. In the meantime, a nature's time bomb is ticking away.

- V HELEN NANCY, R NAGAJOTHI and R VARALAKSHMI

II B.Sc

1+1=2!!

While lecturing on ideal gases one day, Ludwig Boltzmann casually mentioned a number of complex calculations, with which he apparently assumed his students were equally familiar. Near the end of the class, the students, utterly unable to follow his progress, asked Boltzmann to do his calculations on the blackboard. The professor apologized and promised to do better next time. Soon enough, the next lesson arrived. "Gentlemen," Boltzmann began, "if we combine Boyle's Law with Charles' Law we get the equation pv = psub 0 vsub 0 (1 + a t)... Now it is clear that sub a S sup b = f(x) dx x (a), so pv = RT and sub V S f(x,y,z) dV = 0... It is as simple," he declared, "as one and one equals two." Then, suddenly recalling his promise from the previous class, he dutifully wrote "1 + 1 = 2" on the blackboard before continuing with the lecture.

THE LAB-YRINTH!

In this age of war and grief
You never would've seen
a riot, yes a riot alright
That now seems comic relief.

Was it nerves or sheer strain?
Or that dragon of a burner?
That left you soaked all through
As though drenched in the rain.

Butter fingers forever, at that,
Never would a test tube stay
Between fingers that never fielded
(Thank God! For a mercy like that!)

Like a Blitzkrieg, t'would all come down
Test tubes, glass rods all like,
With a deafening roar, and suppressed smiles
Consoling the antiques of a failed clown.

Hop, skip and jump between tests
Try as you may, at the speed of light
Never on time, will you reach to
Put an overflowing beaker to rest.

A yellow complex? Not at all.
Earwax would be closer
To a new shade I've
Arrived at after all!

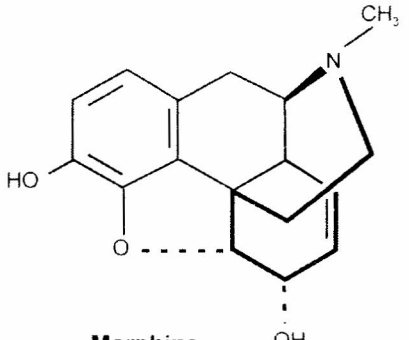
Hark! What's that I hear?
The creation of another universe?
Something's blown up and that that's the cause,
Isn't it crystal clear?

I've hit gold, I've hit gold!
I'm no alchemist, dear
My report's alright (much to my delight!)
Is what I've been told

- **BHARATHI RAMASUBBAN** III B.Sc

ENDORPHINS- THE HAPPY HORMONES

Endorphins or endogenous morphines are a group of chemical neurotransmitters released by the neurons in our body, much like acetyl choline. They are opioid neuropeptides, which are produced by the pituitary gland and the hypothalamus. Endorphins were discovered by John Hughes and Hans Kosterlitz As the name suggests, they are structurally similar to morphine. Besides they activate the same receptors in our body as the opiates and have similar effects.



Morphine

The first endorphine molecule was isolated in 1975 but their existence had been predicted much earlier. There seemed to be receptors on neurons in the human body that are specific to molecules synthesised by the poppy plant. There had to be some molecules released by our body that play the same role. Hence endorphins (which translates roughly to 'the morphine within') were discovered.

There are 3 types of Endorphins:

- Enkephalins
- Endorphins
- Dynorphins

One of the effects of endorphins is analgesia or 'pain killing'. They are part of our primitive defence system and are released immediately during injury and produce numbness for a short period, which enables one to run to safety or shelter. Another effect is euphoria or a happy, content feeling. Endorphins are released when activities essential for survival such as eating, exercise etc are performed. They make such activities pleasurable and stimulate repetition of such activities in the future.

More endorphins have been isolated since then and scientists are trying to synthesise them to be used as anti-depressants etc. This is because endorphins are less harmful and less addictive than morphine, heroin as they are easily broken down by enzymes in our body.

- NISHA VINAYAK I B.Sc

CHEMICAL POLES

"In Science you do not need to be polite, you only need to be right."

– Winston Churchill

Many do not realise that Science is fuelled by cut throat competition. There are no prizes for second place in the annals of Science. Since ancient times, rivalry has been a key feature of scientific endeavour.and a powerful impetus for the greatest advances in western science. One such instance where rivalry played a driving role in the advancement of science and technology is the discovery of oxygen and it's properties.

PARIS, MAY 1794:

The French Revolution was at its vicious best and Lavoisier, the aristocrat, was being taken to the guillotine. As the blade struck the frame, his well-manicured hands fell lifeless to the ground with blood staining his brocaded coat. At that moment, his bitter rival, the English Chemist, Joseph Priestley, was seated in a cabin aboard a ship heading for the New World, not knowing what the future held for him. Priestley was appalled by the news from Paris because it could so easily have been his head in the guillotine (Priestley was fleeing from France since he had been mistaken for an aristocrat and condemned to death). His thought went two decades backward when the seeds of rivalry between the two greatest chemists of the time were sown, resulting in the discovery of oxygen.

Though it was Joseph Priestley who discovered oxygen, he had no idea what he had found. It was Antoine Lavoisier who, in spite of discovering nothing, understood Priestley's findings and was responsible for interpreting the significance of oxygen in combustion. They shared scientific friends including the great Benjamin Franklin but that was all they had in common. They were from rival nations, diametrically opposite religious faiths; one was immensely rich and the other poor. The two men had met only once at a dinner engagement in the October of 1774. This meeting of the two Chemistry giants proved to be a pivotal occasion. Priestley spoke freely of his finding and discovery of oxygen from mercuric oxide and red lead. For Lavoisier, Priestley's candid talk opened the door to the combustion puzzle, which had till then remained a big mystery to him.

Though a fine experimental chemist, Lavoisier was not the first to isolate oxygen. Many of his works seem to be based upon the works of others. No wonder Priestley considered him a plagiarist. Rather than understanding his discovery, Priestley's main motive seemed to be his quest to prove Lavoisier wrong. In doing so, he lost his scientific judgement.

This is a poignant tale in the history of Science where rivalry played a central role in its advancement.

- **KAAVYA KRISHNA KUMAR** II B.Sc

THE KILLING OF THE SPIRIT AND THE PERSON

The world of sport was shocked when Canadian, Ben Johnson was denied his gold medal at 1988 Olympics after tests showed he had taken anabolic steroids. Every year professional athletes try to get just a "little bigger," a "little stronger" to prove to the world their supremacy. Even turning to anabolic steroids to gain competitive advantage seem to be OK.

Anabolic steroids are hormones derived from cholesterol and belong to a group known as **ergogenic** or performance-enhancing drugs. The following is the list of drugs banned internationally by the sports world:

(a) Stimulants: amiphenazole, amphetamine, bemigride, benzphetamine, bromantan, caffeine, chlorphentermine, cocaine, doxapram, ephedrine, ethylamphetamine, methylene dioxymethamphetamine (Ecstasy), strychnine, and related compounds.

(b) Anabolic Agents: anabolic steroids, androstenediol, androstenedione, norandrostenedione, norethandrolone, testosterone and related compounds.

Offence of using the banned drugs can be tested by: urine drug testing, blood drug testing, saliva drug testing, hair follicle drug testing and breath-alcohol tests. Positive testing simply indicates that a drug was used in the recent past, but fails to decide if the person was currently under its influence.

Urine test is the most common method of testing: the sample's temperature, freshness, specific gravity, pH, and creatinine (shows up as a solid yellow color) Even traces of marijuana, amphetamines, Ecstasy, LSD, heroin, cocaine, anti-depressants etc. can be identified by estimating therapeutic concentrations of acemetacin, acetaminophen, acetylsalicylic acid, fenbufen, fenoprofen, flufenamic acid, flurbiprofen, ibuprofen etc by a gas chromatographic–mass spectrometric (GC–MS) screening. Plasma analysis successfully employs estimation of the metabolites in urine.

Though success is heady, the side effects far outweigh the rewards: men suffer from shrinking of the testis, impotence, baldness, pain in urinating, development of breasts and enlarged prostrate; while women experience growth of facial hair, changes in the menstrual cycle, enlargement of the clitoris, deepened voice and breast reduction.

Is it worth the attempt after all?

- MADHUMITA I B.Sc

SERENDIPITY IN CHEMISTRY

"— you do not reach Serendip by plotting a course for it. You have to set out in good faith for elsewhere and lose your bearings... serendipitously."

- **John Barth**, The Last Voyage of Somebody the Sailor.

The world of discoveries is indebted to the English author **Horace Walpole** for coining the word "**serendipity**". He says in one of his letters dated January 28, 1754, that, "this discovery, indeed, is almost of that kind, which I call serendipity. A very expressive word." Perhaps, the word itself came to him by serendipity. The Oxford English Dictionary defines serendipity as "the occurrence of events by chance in a fortunate way." It may also be the faculty or phenomenon of finding valuable or agreeable things not sought for. Walpole coined the word from the old name for Sri Lanka, **Serendip**. He explained that the name was part of the title of a silly fairy tale called "*The Three Princes of Serendip*".

In this story, three princes from the island kingdom of Serendip (now Sri Lanka) were sent forth by their father, the king, to travel widely in order to acquire the maturity born of experience As fate would have it, their adventures were laden with one unwelcome turn after the other. Fortunately, each misadventure turned to their advantage making them stronger and wiser for their royal responsibilities.

Many important scientific discoveries have occurred because researchers pursued 'chance' or accidental events. Nowhere is this more evident than in the history of polymers and organic chemistry.

In the **1870s**, Louis Pasteur was involved in an effort to save the French silk industry from an epidemic that had inflicted silkworms. His assistant, a young chemist, **Hilaire de Chardonnet**, spilt a bottle of collodion while working in the dark room. Like many of us, he did not clear the mess immediately. When he returned to clean up his mess, he found that the collodion had become a tacky, viscous liquid due to partial evaporation of the solvent. As he wiped it away, he noticed long, thin strands of fiber, which resembled silk. His strong desire to find a silk substitute encouraged Chardonnet to experiment further with the collodion. Six years after the accidental spill, a material closely resembling silk had been produced. The unveiling of this artificial silk took place at the Paris Exposition of 1891, where it was enthusiastically accepted for commercial production. This new fiber called **rayon** had its humble origin in a wash sink.

Another classic case is that of **Joseph Priestley**, very often known as the *king of serendipity*. In case you didn't know already, Priestley had no real interest in science. In fact, he never took a single formal course in science. He lived next to a brewery and was intrigued by the air that

floated over the fermenting grain. He was able to show that this brewery gas extinguished lighted wood chips. He also noticed that this gas drifted to the ground around the vat, implying that it was denser than normal air. This gas would later be identified as carbon dioxide. When the *heavy gas*, as he called it, was dissolved in water, he found that it had a very pleasant and tangy taste. For this unexpected invention of soda water, he was elected to the French Academy of Sciences in 1772 and received a medal from the Royal Society in 1773 (unbelievable, yet true!)

In 1856, an eighteen-year-old chemistry assistant, **William Henry Perkin**, undertook the project of trying to synthesise the anti-malarial drug, quinine, on his Easter vacation. He started with a simple waste product, aniline, from coal tar. He failed at synthesizing quinine but did produce a mysterious black powder. Given his curiosity, he tried to discover what it was. He soon found that the powder dissolved in alcohol to produce a stunning purple color. Instead of discarding the solution, Perkin wondered if it might dye fabric. He found that not only did it color silk and cotton, but the color did not wash out with soap or fade when exposed to sunlight. Perkin built a factory to produce his **Mauve dye** catapulted a curious teenager to a millionaire.

Most artificial sweeteners have been accidentally discovered: **Ira Ramsen**, one day in1878, had dinner without washing his hands, found the food very sweet & tumbled upon ***Saccharin***. In 1937 **Michael Sveda** while smoking a cigar in the lab, found it extremely sweet, and went on to isolate ***Cyclamate***. While researching anti-ulcer drugs in 1965, **James Schlatter** came across ***Aspartame***, the cornerstone of the sweetener industry.

Many more are the discoveries, which were hit upon by sheer chance. So, the next time your experiment fizzles out, just do not hasten into washing your apparatus. Maybe you have just come up with something new!

- **NIRUPAMA RAMAN** (II B.Sc)
- **BHARATHI RAMASUBBAN** (III B.Sc)

RUTHERFORD'S TRANSFORMATION!

One day in 1908 the famed physicist Ernest Rutherford was delighted to learn that he would soon be awarded a Nobel prize for his work on radioactive decay. However Rutherford (who once remarked that "all science is either physics or stamp collecting") was less delighted to learn that, because his work was not regarded as physics, his would be a Nobel prize in chemistry (a discipline then regarded with disdain by many physicists). In his acceptance speech, Rutherford could not help but remark that, while he had observed many transformations in the course of his work, he had never seen one quite as rapid as his own - from physicist to chemist!

INVESTIGATING HUMAN EVOLUTION

The greatest journey ever undertaken left behind a trail of unanswered questions: How did our species arise and spread around the globe to become the most dominant creatures on the planet? Part of the answer came two decades ago, when geneticists stunned the world with the finding, that all humans alive today can claim as their common ancestor, a woman who lived in Africa about 150,000 years ago. But while the notion of an African origin of the humans has grown to be accepted by most scientists, the details of how they swept out of Africa to populate the rest of the world remained vague. For the last 15 years or so, molecular anthropologists have been comparing the DNA of living humans of diverse origins to build evolutionary trees.

In July 1997, a team of German and American researchers led by Svante Pääbo extracted mitochondrial DNA (mtDNA) from the first recognized Neanderthal fossil. Unlike nuclear DNA, which is equally inherited from both parents, mtDNA is inherited only from the mother because the mtDNA in the sperm degrades during fertilisation. Therefore mtDNA does not undergo genetic reshuffling. Hence it was concluded that mtDNA of all living humans is inherited from a single woman at the apex of the genetic pyramid, who is known as Mitochondrial Eve. However, like all DNA, mtDNA mutates occasionally so that one of the bases changes. Because of these mutations, human mtDNA has been slowly diverging from that of mitochondrial Eve, and the amount of mutation is roughly proportional to the time that has passed.

After death, DNA starts degrading immediately. However, some DNA fragments can survive for as long as 50,000 to 100,000 years. Polymerase Chain Reaction (PCR) is a technique, which can be used to create many copies of an initially small number of molecules. The researchers used PCR to amplify and extract many short strands of mtDNA from the Neanderthal sample.

The use of mtDNA to investigate human history is not without drawbacks. There are suggestions that paternal mtDNA can sometimes be inherited, which could affect analyses so far. However, there is no explanation as to how recombination could occur. If mixing is common, it could mean that there was no mitochondrial Eve after all!

So, does that mean we have come back to square one?

- T K SREEVIDHYA II B.Sc

LAYMAN'S WORLD OF SCIENCE

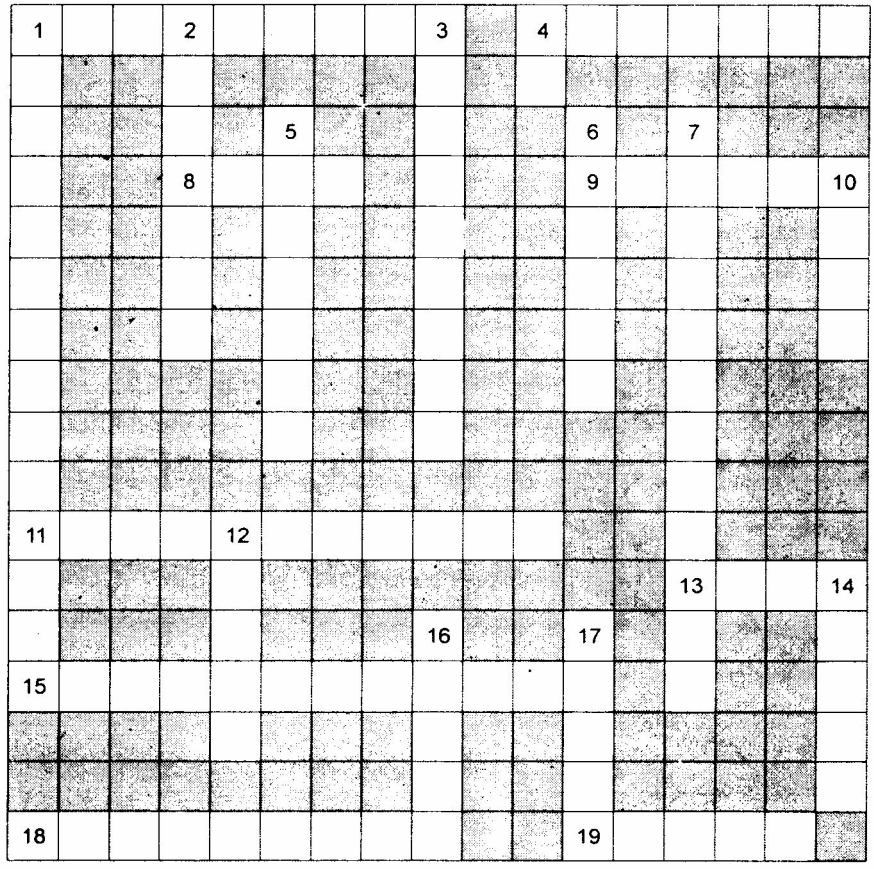
Ever wondered why the sky is blue, why tincture makes your skin burn or why we get goose bumps? Well, we put forth some questions of this kind to our friends and it was indeed interesting to see how much they really understood Science!

1) Why is red used as the colour of danger?
   - "B'cos red is the colour of BLOOD." (In a tone that was enough to scare any murderer away!!!)
   - "B'cos red is my favourite colour." (We're not taking a "favourite colour" poll here!)
2) Why do onions make you cry?
   - "Hmmm...b'cos I don't like them." (She actually thought to come up with that answer!!!)
   - (Our favourite answer by far) "There was a carrot, a tomato and an onion. When the tomato died, the carrot and onion cried. And then the carrot died (due to what unfortunate circumstances we still don't know!). And this time the onion wept, not only b'cos it lost it's buddy but b'cos it didn't know who would be there to cry when it died. Seeing the sad state of the onion, God decided that people would cry every time they cut an onion!!! (No, we did not ask an LKG student!)
3) Why do chocolates make you happy?
   - "B'cos they're sweet." (Well, maybe that too!!)
   - "They're just yummy and you can drown your sorrows in them."

After those rather entertaining answers, let's get down to some real Science facts.

1) In the series of colours VIBGYOR, red has the longest wavelength and hence can be seen the farthest. A lot of people actually came pretty close to the answer by saying that it was a bright colour and that it caught the eye.
2) When you slice through an onion, you break open a number of onion cells. Some of these cells have **enzymes** inside of them, and when they are sliced open, the enzymes escape. The enzymes then decompose some of the other substances that have escaped from sliced cells. Some of these substances, **amino acid sulfoxides**, form **sulfenic acids**, which then quickly rearrange themselves into a volatile gas. The gas reaches your eyes and reacts with the water that keeps them moist. This changes the chemical's form again, producing, among other things, a mild **sulfuric acid**, which irritates the eyes. The brain reacts by telling your tear ducts to produce more water, to dilute the irritating acid so the eyes are protected.
3) The cocoa beans used in the manufacture of chocolates trigger the release of Endomorphins, which are 'happy hormones'.

CROSSWORD



CLUES:

Across:

1. Granular explosive used by Guy Fawkes (9)
4. Anti anti pane (7)
8. The vermin of the society; born of soap (4)
9. Polysaccharide from dahlia tubers and Jerusalem artichokes (6)
11. Space age material used in Tennis racquets (11)
13. ..... Nitrite in Swamy lives (used to relieve attacks of angina) (4)
15. Little Bo Peep who loses water to the atmosphere and breaks into bloom (12)
18. Headless trophy silently in right turns into light sensitive compound in biological systems (9)
19. Tree sap in sincere sin (5)

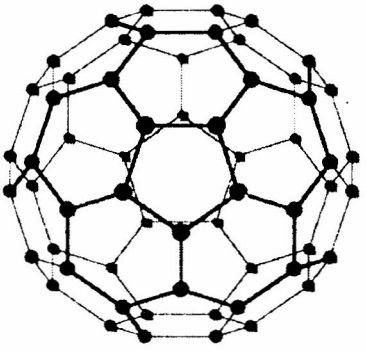
Down:

1. Youngest in the family of sweet people (14)
2. Present in plant cells; reservoir of starch and oil (8)
3. The most obvious corrosion product on the Titanic (9)
4. Element named after a Titan who stole fire from the Gods (2)
5. The process of linking this element to polymers, is named after Roman God of fire (7)
6. Hernia Cinderella has is a vitamin (6)
7. Computational tool that solves Schrodinger's equation (7,5)
10. The element which means new in Greek (4)
12. The discovery of this polymer is a classic example of serendipity; used as a silk-substitute (5)
14. Distinguishing test for alcohols (5)
16. Protein which drives muscle locomotion (5)
17. Was one of first anaesthetics used; it is there, confused!

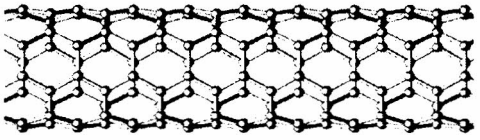
(For Solution, look up page 29)

SMALL IS BEAUTIFUL

Nanomaterials have become the major subject of interest in the recent years. They are a new class of Carbon-based materials related to Buckminster Fullerenes. Carbon nanotubes were discovered by **Sumo Ijiyama** of **Japan**. He found them as deposits of soot while producing C-60 by arc discharge method. They are formed by rolling graphite-like sheets and their ends are capped with hemispheres of bucky ball.



Buckyball



Nanotube

Buckminster Fullerenes (C60) are cage-like molecules with the geometry of a geodesic dome. They are obtained by the resistive heating of graphite in an inert atmosphere. In fact, nanotubes were discovered during the production of C60 by arc-discharge method. Fullerenes are highly stable carbon clusters with a network of 5-membered and 6-membered rings. The only difference between nanotubes and fullerenes is that they are made up of only six-membered rings while the latter have both 5 and 6-membered rings in their network.

Nanotubes have great application as conductors and semi-conductors. They are also used as memory devices and help cell immobilisation and transport measurement through biological molecules.

- **DEEPIKA VISWANATHAN** I B.Sc

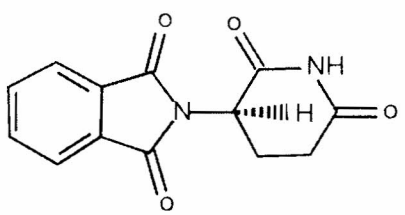
Dr. JEKYL AND Mr. HYDE?

However much the world may change and speed forth in a mad frenzy leaving no time for emotions, there are some things that never change. Like the birth of a child is forever a joyous occasion. It evokes a new zest for life, bringing along with it a package of dreams, aspirations and a bundle of joy to the parents. But imagine waking up to a rude shock and finding that this perfect picture is not quite complete.

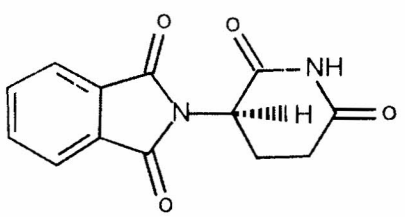
This was precisely what happened in 1960 in UK and parts of Canada. The reason behind this was the drug named Thalidomide. It was patented by Chemie Grunenthal and was prescribed to treat morning sickness in pregnant women. It was certainly successful in treating morning sickness but its effects were to linger on for much longer. Thalidomide was responsible for 12000 children being born with tragic birth defects. It puts the foetus at risk of injuries, including eye and ear defects and severe internal defects of the heart, genitals, kidneys, digestive tract (including lips and mouth), and nervous system. Its teratogenic action was very prominent because morning sickness occurs at the time of foetal limb development.

α - (N-phthalimido) glutarimide or thalidomide, is a glutamic acid derivative. The structure of the molecule shown below is a two-ringed structure with an asymmetric carbon in the glutarimide ring. The molecular formula is C_{13} H_{10} N_2 O_4 and its molecular weight equals to 258.2. This chemical exists as an equal mixture of S(-) and R(+) enantiomers that rapidly interconvert under physiological conditions. The ingredients of each capsule of Thalidomide include anhydrous lactose, microcrystalline cellulose, polyvinylpyrrolidone, stearic acid, colloidal anhydrous silica, and gelatin.

It might sound unbelievable that enantiomers differ vastly in their physiological properties, to the extent that one might be a harmless drug and the other a potent poison. This holds good in the case of Thalidomide.



(R) - Thalidomide desirable properties: sedative and antinausea drug



(S) - Thalidomide teratogenic: causes birth defects

Laboratory tests after the 'Thalidomide disaster' showed that in some animals the 'R' enantiomer was teratogenic but the 'S' isomer was an effective sedative. It is now known that even when a stereo-selective sample of thalidomide (only one of the optical isomers) is administered, the pH of the blood, can cause racemizing. This means that both enantiomers are existent in a roughly equal mix. So, even if the drug contained only the 'S' isomer the disaster could not have been averted.

- R. SOWMYALAKSHMI II B.Sc.,

THE CHEMISTRY IN OUR LIVES

"In me are hidden constellations....."

- Roald Hofmann

BREATHING & BOYLE'S LAW

We breathe about 12 times a minute, each time inhaling or exhaling about 500 ml of air. During breathing-in, we lower the diaphragm or raise the ribcage, increasing the volume of the chest cavity. In accord with **Boyle's Law**, the pressure in the chest cavity is decreased & becomes lower than the outside pressure. Air thus flows from outside the body into the lungs, though the difference is only of **3mm Hg**. In exhaling, we reverse the process. During severe breathing problems, artificial respirators maintain a pressure lower than the atmospheric pressure, causing the patient to breathe in.

CIS-TRANS ISOMERISM IN VISION

Retina, the light-detecting layer at the back of the eye, contains a reddish visual pigment, **Rhodopsin,** which is a combination of one molecule of the protein **Opsin** and one molecule of **11-cis- retinal**. When light hits rhodopsin, the less stable **11- cis** double bond is converted into the more stable **11- trans**. This configurational conversion changes the shape of the opsin part of the molecule, causing a 'firing' of neurons in the optic nerve, leading to visual stimulus, which is processed by the brain to produce vision. The central portion of the retina contains the 'cones' (for color vision) & the remaining area has 'rods' (for night vision). 11-cis- retinal is found in both rod & cone cells; but while cones have three kinds of opsin for three colors, rods have only one.

REDOX REACTIONS IN SUNGLASSES :

Photochromic glass can change from transmitting 85% of light to 22% when exposed to bright sunlight. It is composed of linked tetrahedrons of Si and O atoms jumbled in a disorderly way, with crystals of AgCl caught between the silica tetrahedra. When the glass absorbs **UV** light, this energy triggers a **redox** reaction between **Ag^+ and Cl^-** :

$$Ag^+ + Cl^- \xrightarrow{\text{UV light}} Ag^0 + Cl^0$$

To prevent the reaction from reversing immediately, a few Cu^+ ions are incorporated into the AgCl crystal, which react with the newly formed Cl atoms:

$$Cu^+ + Cl^0 \longrightarrow Cu^{2+} + Cl^-$$

The Ag atoms move to the surface of the crystal and form small colloidal clusters of Ag metal, which absorbs light, making the lens appear dark. As the glass is removed from the light, the Cu^{2+} ions slowly move to the surface of the crystal where they interact with Ag:

$$Cu^{+2} + Ag^{0} \longrightarrow Cu^{+} + Ag^{+}$$

The glass looks clear as the Ag^{+} ions rejoin Cl^{-} ions in the crystals.

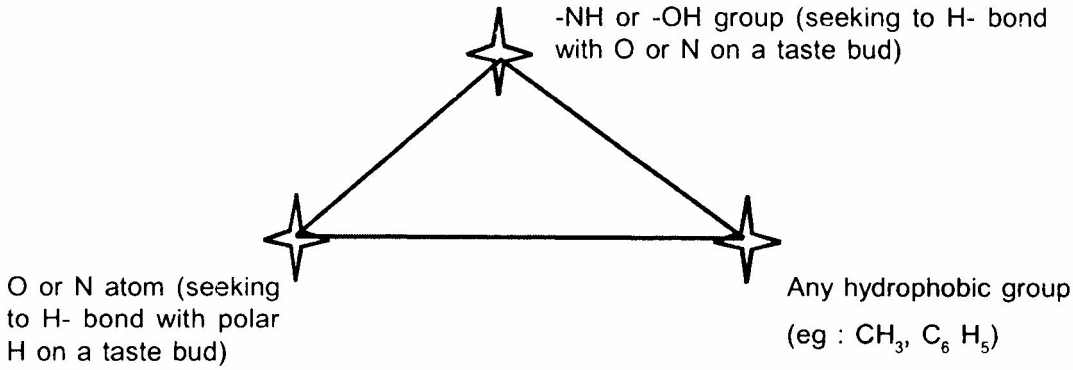
Wear Glasses. Save the light of your life.....

DANGEROUS: High or Low Body Temperature

At the normal body temperature, 37°C (98.6°F), the many reactions in the body – respiration, digestion etc occur at desired rates. Fever is a protective mechanism; a small increase in temperature kills germs by increasing the rates of the defense mechanism; breathing is faster to supply sufficient O_2 for the fast reactions. An increase of even 3°C (104°F body temp) raises reaction rates to the **danger point** and if that temp sustains it causes mortality. On the contrary, during a heart surgery, surgeons deliberately lower body temp to 25°C (86°F), reaction rates are lowered, the oxygen requirement is brought down to 50% and the heart or lung can be effectively de-linked. **So, stay cool, stay fit.**

THE TASTE OF CHEMISTRY

The Triangle of Sweetness diagram explains how humans perceive sweetness:



The proteins in our taste buds form Hydrogen bonds with the OH, NH_2 groups & also with the hydrophobic region in the sweetener molecule at 3 points. Sweetness is particularly responsive to the taste buds at the tip of the tongue.

That 'Sweet' Tooth

The outermost layer of tooth, the enamel, is 5% collagen & 95% Hydroxyapatite, HAp, insoluble in water & so protective of the tooth. Bacteria, which ferment remnants of food, produce acid, which dissolves HAp. Using a Fluoridated toothpaste, the OH^- is exchanged for F^-, forming the less soluble Fluoroapatite (K_{SP} = 1.5X 10^{-10}) than HAp (K_{SP} = 4X 10^{-6}).' **Take care. Take in Fluorides.**

However when there is tooth loss, dentists install temporary crowns made of Al. If there happens to be a Au crown in another tooth, the mouth might then become the site of a **Galvanic cell**, the oral fluid acting as electrolyte for the redox reaction. This electrical activity stimulates nerves & causes further pain.

SWEETNESS IN LIFE: a chemical connection

It is possible that the Touch of Love and emotions that trigger romantic relationships are governed by **â- phenylethylamine** (PEA), which functions as a neurotransmitter, creating excited, alert feelings and moods. Levels of **PEA** can be measured in terms of its metabolite, Phenylacetic acid : increased levels give the feeling of **"being in love"**, whereas low levels correlate with depression. Though no food sources can directly increase PEA levels, protein rich foods contain phenylalanine, a precursor of PEA. **Perhaps the way to your true love's heart is through the stomach after all!!**

AGE & Ageing

The **amino** group in protein can react with the **carbonyl** group in carbohydrates, establishing a link between the two moieties (glycation of proteins). When these linked products are heated, high-molecular-weight water-insoluble brownish complexes called "Advanced Glycation End products" **AGE** are formed. The higher the blood sugar, AGE products accumulate more. Thus in diabetic patients, they affect the lens of the eye (cataracts), the retinal capillaries (diabetic retinopathy) and the glomeruli of the kidneys (kidney failure). With age, metabolism slows down and the **AGE products** cannot be decomposed & so they accumulate, leading to enhanced oxidative damages and **aging**. **An irreversible process, so far.....**

LIFEGEM 'Time shall not wither the Dear Departed'

The wonder element, **carbon**, exists in nature as graphite, diamond and fullerene.

Recently a US company has come up with a scheme to filter the carbon from the **remains of the deceased loved ones & converting it into diamonds** (a fee of $3000 for a 0.25 carat product). With an average body containing 16 kg C, the idea doesn't seem far-fetched at all.

Another UK Company offers to commemorate them in precious stone/gold. By **'selective element recovery'** of the body contents: the 1kg Ca (from bones) can be turned to a designer urn, with color glazing from the 50 mg Cd (micronutrient) or the 4g Fe (from hemoglobin) can be crafted to a wrought iron brooch, to continue to remember them as part of the household. **A fitting tribute indeed!!**

CHEMICAL MOLECULES are at the HEART OF LIFE...

- Dr. JESURIETTA SATHIAN
Faculty, Dept. of Chemistry

EXPLOSIVE SITUATION

"On the eve of World War I, the chemist Chaim Weizmann - a fiery Zionist [and future Israeli president] working in England - discovered a way to put a particular strain of bacterium to work synthesizing the compound acetone in the course of its fermentation of grain. Acetone supplied the essentials for the manufacture of cordite, and thus guaranteed Britain a war-long supply of explosives. It was partly in response to Weizmann's achievement that the British government was induced, in 1917, to put forth the Balfour Declaration agreeing to the re-establishment of a Jewish national state in Palestine."

In other words, the incendiary situation in the Middle East was, ironically, literally fueled by the development of explosives!

THE CHEMISTRY OF COSMETICS

The cosmetic industry involves more than five thousand ingredients. These include moisturizers, preservatives, anti-microbials, thickeners, solvents, emulsifiers, inorganic compounds, pH adjusters, anti-oxidants etc. In all these, the miracle cosmetic ingredient is α -hydroxyacid (AHA, R-CHOH-COOH). Mankind has exploited, unknowingly though, the beneficial effects of AHA on skin, long before its isolation, identification of the chemical structure or its use. Egyptian women taking bath in sour milk, the French women washing their face in old wine, all for improving the condition of skin, were existent even in the times of King Louis the XIV!

Today, α-hydroxyacids are used extensively in cosmetic dermatology at concentrations lower than 10%. They are regularly formulated into everyday use creams. At higher concentrations, AHAs function as peeling agents, which act more rapidly, and at a deeper level. Glycolic Acid is the most commonly used AHA. Because of its small molecular weight and size, it is presumed to have a better capacity to penetrate skin. Glycolic acid peels at concentrations of 20-70%, and is commonly used by dermatologists and plastic surgeons to remove severe acne scarring and skin pigmentation irregularities. Glycolic Acid is commonly present in honey and sugar cane.

The full mechanism of action of AHA is not yet fully understood by researchers. It is known however, that they function in two distinct fashions: First, they can act as a simple humectant that absorbs moisture from the atmosphere. When applied to the skin, these hydrated AHAs act to increase the water content of the skin and thus moisturize the outer layer of the epidermis and consequently make the skin softer and more flexible. The second method by which AHAs are thought to act is by reducing corneocyte adhesion and accelerating cell proliferation within the deeper basal layer of the skin. This exfoliating action of AHAs occurs as a result of their ability to break the bonds between dead skin cells that form at the surface of the skin. Skin normally has a dead layer of cells at its surface, and AHAs can speed up the normal process of skin cell regeneration and sloughing. This results in increased flexibility of the skin as well as decreased formation of large dry skin flakes at the surface of the skin.

Although alpha-hydroxy acids appear to be the miracle cosmetic ingredients, there are some genuine safety concerns associated with their extended use. AHAs can however safely be used at a concentration of 30% or less and at a pH of 3.0 or greater. The next time you stand before the mirror and use cosmetics just pause for a moment and think about all that goes into it.

- Dr. MARY TERRY
Faculty, Dept. of Chemistry

REACHING SCIENCE AND TECHNOLOGY TO RURAL WOMEN

With a mission of reaching out science and technology to rural women, the Department of Science and Technology, Government of India, New Delhi has sanctioned a project "**Low Cost Processing and Preservation of Horticultural Products**" to Stella Maris College, Chennai. The project is focused at imparting scientific knowledge and training to rural women and helps them to scientifically process and manufacture food products in an economically viable way. The project is coordinated by Dr.Geetha Swaminathan, Reader, Department of Chemistry, Stella Maris College, Chennai.

The faculty of Stella Maris College would be involved in imparting scientific training to the village women in manufacturing and storage of the fruit produce. The training would be conducted at Stella Maris College premises and at the nodal unit. The training on fruit and vegetable processing and preservation would help in generating self employment for women and uplifting their economic status.

The project is being operated at the field area of 15 villages located around Padappai village, Padappai block- Kunrathur Panchayat union, Sriperumbudur Taluk, Kancheepuram district. The low opputunities for employment, poverty, illiteracy and poor marketing techniques contribute to the poor status of the women in villages. About 20-40% of the produce is wasted due to poor storage and lack of technology in processing. Hence, scientific approach to this problem would help in improving the manufacture and marketing of food produce.

The Objectives of the project are:

- To impart institutional training and field training to the local women which would help in working towards trail production and help in harnessing the local produce and work towards trail marketing and follow up with full fledged production and marketing.
- To set up a fruit processing unit by choosing a wide variety of products based on the availability of local horticultural produce and the marketing conditions.
- To impart technical training to 80 women on the processing and preservation techniques of fruits or vegetables.
- To serve as a demonstrating center and model for surrounding villages and facilitate generation of rural and urban employment.

- To generate additional income or employment for rural women and farmers leading to enhanced quality of life.
- To prevent the spoilage or wastage during the glut season at the producing centers by converting them into new categories of processed products.
- To make all the activities self sustaining and economically viable.

Science and technology play a vital role in value addition and economic upliftment of the society. The scientific knowledge about fruit processing, preparation of juice, jam, pickles would help the less privileged village folk to gain more employment and economic independence. Setting up a fruit processing unit based on the availability of local produce and marketing conditions generates both rural and urban employment and help in development of new food products. The project will also help in minimizing the waste and deterioration of fruits that perish quickly. The project emphasizes training the local women and involving them in production and marketing activities with a scientific approach. This would make them more independent, self confident and motivate the surrounding areas to take part.

Besides the village women, the Department of Horticulture and the block development offices have already shown keen interest in these activities. The women in these 15 villages would be motivated to form a women's forum and act as initiators to sustain the activity in the nearby areas. Scientific support from experts, DST and food industries would help in implementing the ideas successfully and hence the activity will definitely become self-sustaining by the end of the project. This project would create ripples in the society and improve the economic status of the areas. The society would benefit immensely from the economic, socio and technical anvils. It would also generate employment to the marginalized. This project which would reach science to the society would also help in educating the rural people about the technological advancement and work towards the betterment of their own selves in the society.

- **Dr. GEETHA SWAMINATHAN**
Faculty, Department of Chemistry

CROSSWORD SOLUTION

1 G	U	N	2 P	O	W	D	E	3 R		4 P	R	O	P	A	N	E
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- **M. SANTHI** III B.Sc.,

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