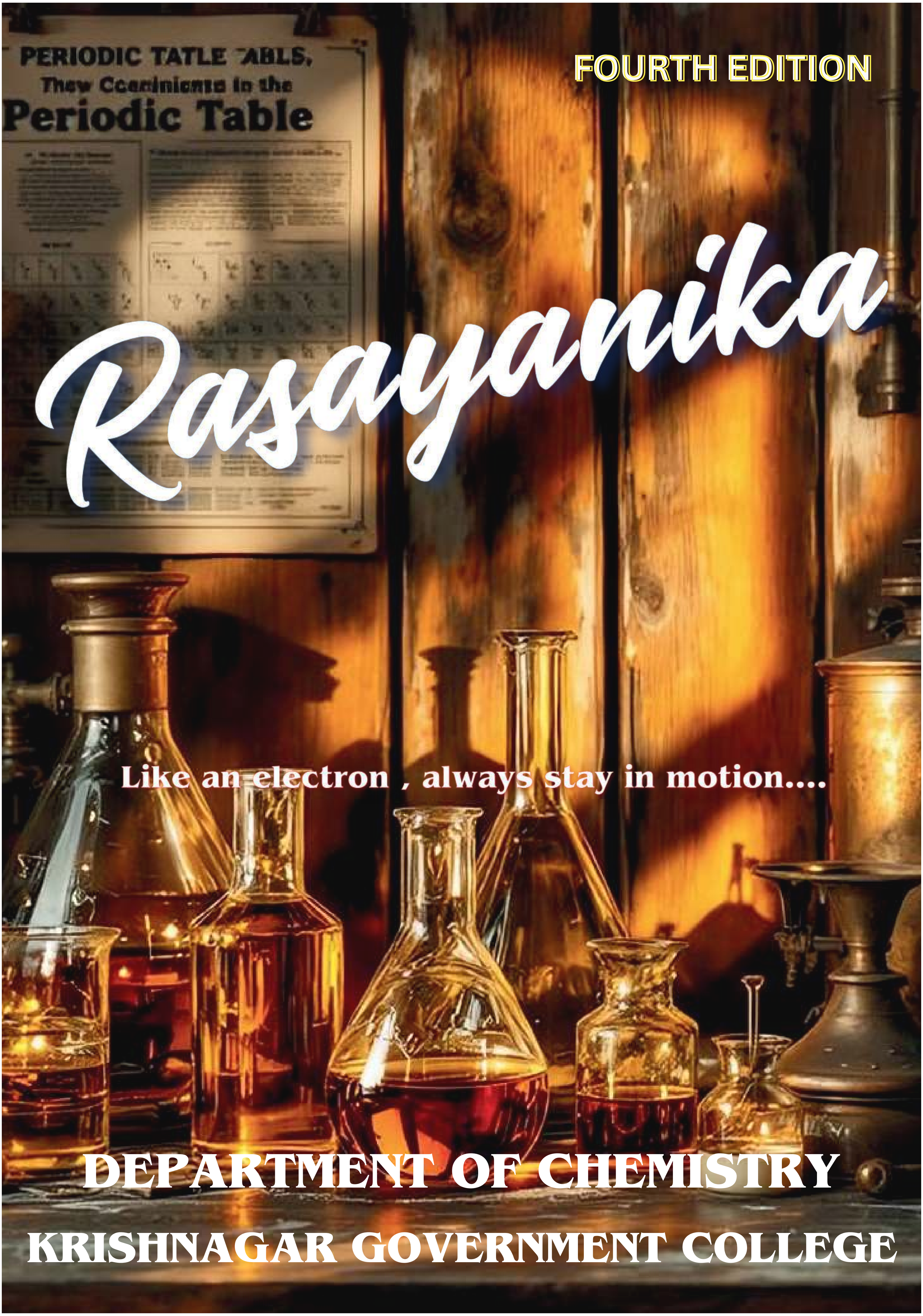
FOURTH EDITION

Rasayanika



Like an electron , always stay in motion....

DEPARTMENT OF CHEMISTRY

KRISHNAGAR GOVERNMENT COLLEGE

RASAYANIKA IV

DEPARTMENT OF CHEMISTRY

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April , 2022

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I am pleased to know and note that students of the Department of Chemistry, Krishnagar Govt. College have successfully upheld the tradition of publishing their annual Departmental magazine RASAYANIKA 2025 for the academic year 2024-25. RASAYANIKA has inspired the students to know about the mystery of Chemistry behind everyday life by instigating the curiosity among the young minds to learn about modern discoveries in diverse fields of Chemistry and encouraged them to cultivate their writing skill

I congratulate all the beloved students and teachers of the Department of Chemistry for bringing out this 4th edition of RASAYANIKA and hope that this edition will enlighten the readers.

Niyogi

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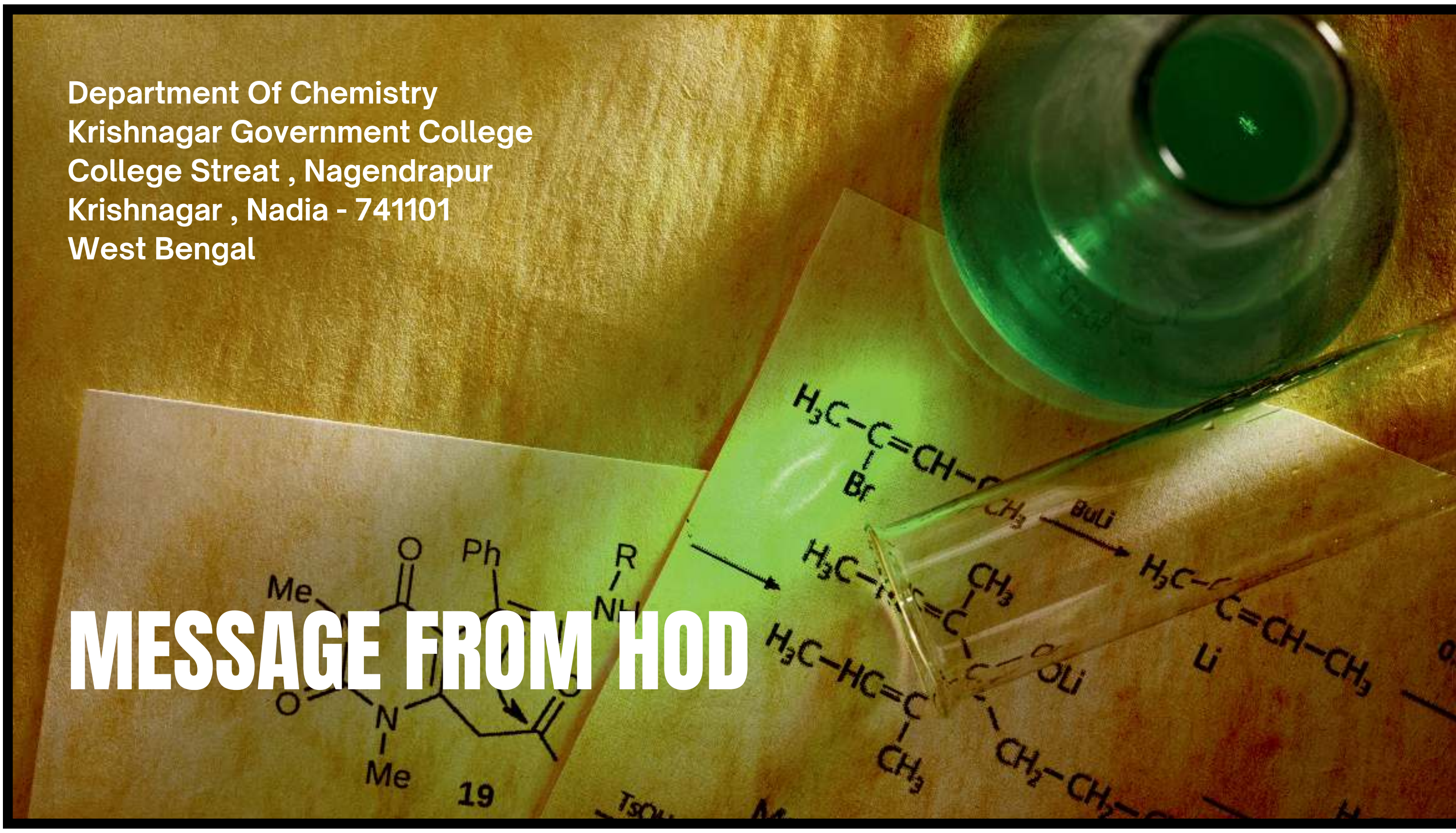

MESSAGE FROM HOD

It gives me immense pleasure to announce the publication of the 4th edition of '**RASAYANIKA**', the annual e-magazine of the Department of Chemistry, Krishnagar Government College. This magazine holds a platform for unveiling the thoughts and creativities of our young chemists. Students of all the three semesters have contributed their articles featuring fascinating facts and various developments in the field of Chemistry. Their curiosity, thirst for knowledge and untiring research work have resulted articles covering diverse topics, ranging from chemistry in space to chemistry behind sunscreen, from finding beauty in nature's creation to mimicking the nature, from pharmaceuticals to nuclear energy. I congratulate all of them, specially the 6th semester students for their hard work in shaping this magazine. I convey my sincere gratitude to our Officer-in-Charge, Dr. Sobhan Niyogi, for his encouragement and support. I am also thankful to all the teachers of this department for their involvement and valuable suggestions. I hope that the present edition of RASAYANIKA will carry through its expectation and will be liked by all.

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Editor's Note

Welcome to thie 4^{th} edition of Rasaynika where the art and science of chemistry come alive beyond textbooks and laboratory walls.

Chemistry, at its heart, is a story of curiosity: a quest to see the unseen, to understand why things change, and to discover how we might change them for the better. For young chemist like us every question we ask — why does this react? what makes colors change? is a step into a world full of wonder. Here we dive into fascinating experiments, fun facts, and stories of scientists who started just as curious as you. Keep asking, keep exploring, and most importantly, enjoy the adventure!

A magazine provides a space for the students to express themselves ,share their ideas through their creative work . It facilitates the communication between students & professeors . Moreover it is a team work that develop valuable skills like writing ,editing & designing .

At Rasaynika, we believe that chemistry is more than experiments and equations . It is a creative journey built on collaboration, curiosity, and wonder. In these pages, you'll also find voices of young chemists , stories of resilience in the lab, and reflections on chemistry's evolving role in society. Together, they serve as a reminder that science is not just about data and formulas . it is a human journey driven by wonder and discovery.

Thanking those who participated actively in Rasaynika's community. We hope this edition inspires everybody to keep asking, exploring, and sharing in the endless story of chemistry.

Enjoy reading!

Table Of Contents

Butterfly: Where Chemistry Meets Nature

Aditi Dutta | Semester VI
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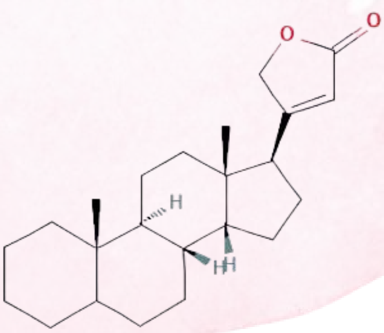
Butterflies are great example of how chemistry exists in nature . From their color of wings to defense mechanism, their existence deals with a fascinating mixture of chemistry & biology.

The colors of the wings of butterflies makes them very attractive & noticeable towards human eyes. But ever we think that what's the chemistry behind it?

Pigments- The brown & black color of wings comes from melanin & the yellow, red orange coloration comes from pterin. It's a type of heterocyclic compound, specifically a bicyclic N-heterocycle called a pteridine, consisting of a pyrimidine ring fused to a pyrazine ring which plays a diverse roles as a cofactor in enzymatic catalysis in coloration in insects & animals For their existence in nature they use different survival strategies .

Toxicity- Some butterflies, like the Monarch, use toxic chemicals to deter predators. Monarch caterpillars eat milkweed, which contains cardenolides (cardiac glycosides) , are naturally occurring compounds characterized by a steroid nucleus, an unsaturated lactone ring (either 5- or 6-membered), and a sugar moiety, with the lactone ring attached at position C17 and the sugar at C3. It causes heart issues in predators.

Mimicry- Some non-toxic butterflies, like the Viceroy butterfly, chemically and visually mimic the appearance of toxic species (like Monarchs) to trick predators. This is an example of Batesian mimicry, which is based on chemical deception.



Cardiac Glycoside

Do you know about killing jar?

Killing jars are used to rapidly kill insects before they are pinned and mounted for collections which is required in research field.

Insects like butterflies, bees, wasps, moths ,flies are kept in a killing jar to quickly and efficiently kill them for preservation, typically using a liquid fumigant like ethyl acetate or nail polish remover, which creates a toxic atmosphere that those insect inhales & soon they falls for death painlessly.

Butterflies are important pollinators and are attracted to flowers by volatile organic compounds (VOCs) released by plants like terpenoids, benzenoids, alcohols, ketones, fatty acids, and esters. Some of other attractants like ,

Lilac aldehyde : Known to elicit strong antennal signals in butterfly species.

oxisophorone epoxide : Found in high amounts in the butterfly bush (Buddleja davidii) and are highly attractive to peacock butterfly pollinators.

For Reproduction , one of the most important part of Butterflies's life cycle they use sex pheromones to chemically communicate. Butterfly sex pheromones contain a diverse mix of volatile compounds, including alkaloids, terpenoids, fatty acid derivatives, and aromatic compounds, often unique to specific species. For example, the male Bicyclus anynana butterfly produces a pheromone blend containing (Z)-9-tetradecenol, hexadecanal, and 6,10,14-trimethylpentadecan-2-ol.

Like all living organisms, butterflies rely on biochemical reactions for survival, including energy production (ATP synthesis), digestion, and development (e.g., metamorphosis from caterpillar to butterfly).

In conclusion, the delicate chemistry of butterflies weaves nature's art and science into a living tapestry. Their iridescent wings and subtle pheromhaones tell a story of intricate biochemical alchemy-a silent symphony that transforms life with beauty and chemistry.

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Failure is like a caterpillar before it becomes a butterfly 🦋

RADIATION TO REVOLUTION : THE NUCLEAR SHIFT

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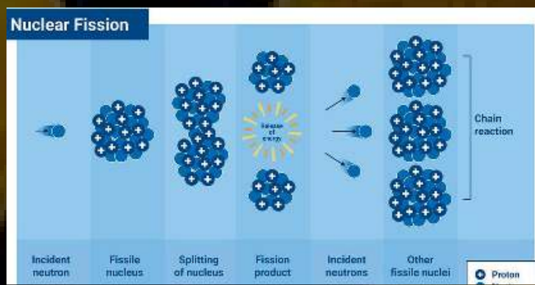
CHERNOBYL INCIDENT :

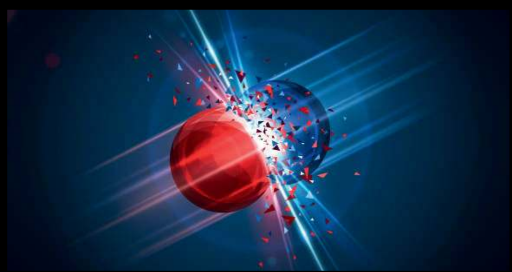
On April 26, 1986 a disaster took place in Chernobyl nuclear power plant, Ukraine. Two plant workers died immediately, and 28 more died from radiation syndrome within weeks. About 350,000 people were evacuated from the area. This incident was caused by a combination of a flawed reactor design (RBMK), operator errors during a safety test, and a lack of safety culture, leading to a steam explosion, fire, and the release of massive amounts of radioactive material.

Nuclear Energy & Chemical Reactions Behind Chernobyl Accident :

Nuclear energy is a form of energy released from the nucleus, the core of atoms, made up of protons and neutrons. Atoms are tiny units that make up all matter in the universe, and energy is what holds the nucleus together. There is a huge amount of energy in an atom's dense nucleus.



Nuclear fission is a reaction where the nucleus of an atom splits into two or more smaller nuclei, while releasing energy. In a nuclear reactor, atoms of uranium are forced to break apart. As they split, the atoms release tiny particles called fission products. Fission products cause other uranium atoms to split, starting a chain reaction.



It is shown that chemical reactions played an essential role in the Chernobyl accident at all of its stages. It is important that the reactor before the explosion was at maximal xenon poisoning, and its reactivity, apparently, was not destroyed by the explosion. The reactivity release due to decay of Xe-235 on the second day after the explosion led to a reactor power of 80–110 MW. Owing to this power, the chemical reactions of reduction of uranium, plutonium, and other metals at a temperature of about 2000°C occurred in the core. The yield of fission products thus sharply increased. Uranium and other metals flew down in the bottom water communications and rooms. After reduction of the uranium and its separation from the graphite, the chain reaction stopped, the temperature of the core decreased, and the activity yield stopped.

How Is Nuclear Energy Utilised Today :

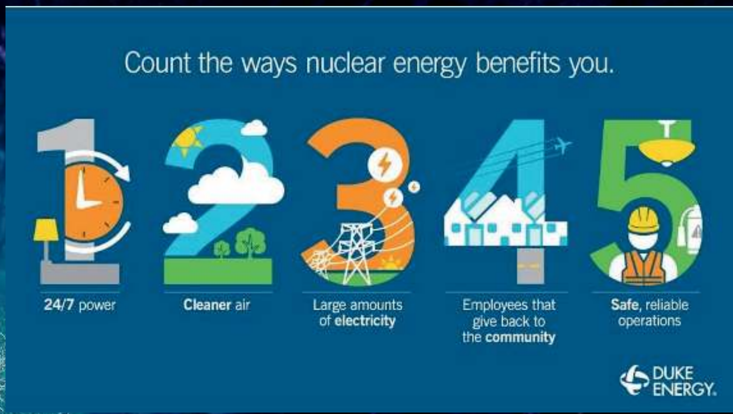
It is very fascinating to think how some simple chain reactions can create such huge outcome. So, the proper uses of nuclear energy is very essential for the survival of mankind. The uses of nuclear energy are -

Electricity Generation: Nuclear power plants use nuclear fission to create heat, which is then used to generate steam and turn turbines, producing electricity.

Medical Applications: Nuclear technology is vital in medical imaging (X-rays, PET scans), cancer treatment through radiation therapy, and the production of medical isotopes used for diagnostics.

Industrial Applications: Nuclear reactors generate heat for processes like seawater desalination and hydrogen production. Radioisotopes are used for industrial measurements and material testing.

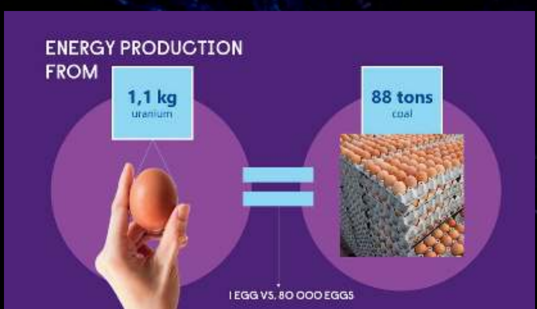
Space Exploration: Nuclear power, especially through radioisotope thermoelectric generators (RTGs), powers long-duration space missions and satellites.



Agriculture: Nuclear technology aids in pest control, crop improvement, and food irradiation, ensuring food safety and enhancing agricultural productivity.

Research: Nuclear reactors support scientific research and provide training for future scientists and engineers.

Naval Vessels: Nuclear propulsion enables naval vessels, like submarines and aircraft carriers, to operate without frequent refueling.

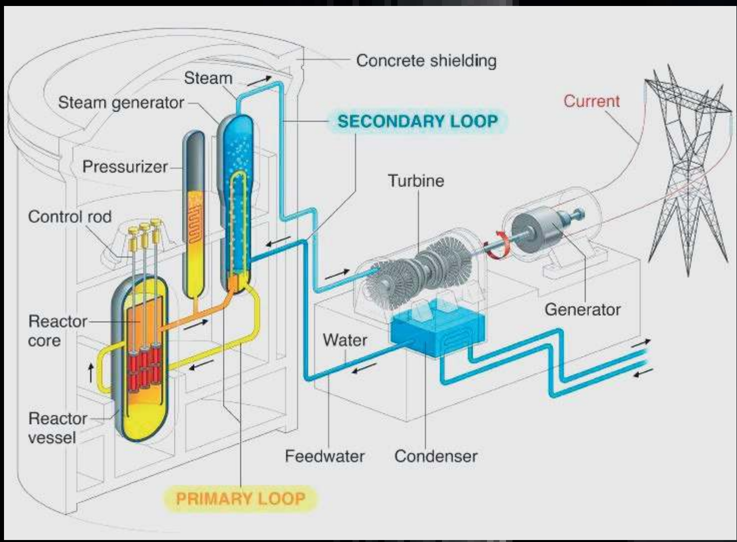


DID YOU KNOW?

A small amount of enriched uranium, typically 4-5 kilograms, can power a nuclear submarine for decades, due to the tremendous amount of energy produced by nuclear fission reactions.

How Does a Nuclear Energy Plant Generate Electricity?

The nuclear chain reaction produces heat inside the reactor vessel and heats water to a very high temperature. Due to pressure inside the system, the water does not boil.This hot, pressurized water flows through thousands of looped pipes, while a second stream of water flows around the outside of the pipes inside the steam generator. This water is under less pressure, so the heat from the pipes boils it into steam.The steam travels through pipes to turbines and spins their blades. The turbine's blades spin the turbine shaft, which connects to a generator. The generator shaft rotates around inside a set of magnets. This creates electrical current.



Conclusion :

Very small amount of nuclear energy can produce much more output than the other known sources of energy. The future of nuclear energy appears to be one of increasing importance as a clean, reliable, and baseload power source, particularly in the context of global efforts to combat **climate change** and achieve **net-zero emissions**. While modern reactors are designed with advanced safety features, the risk of accidents, though low, cannot be completely eliminated. If the reactors are not used carefully then horrible incidents like fukushima and chernobyl can happen again.

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CHEMISTRY OF PACLITAXEL : a natural anti cancer agent

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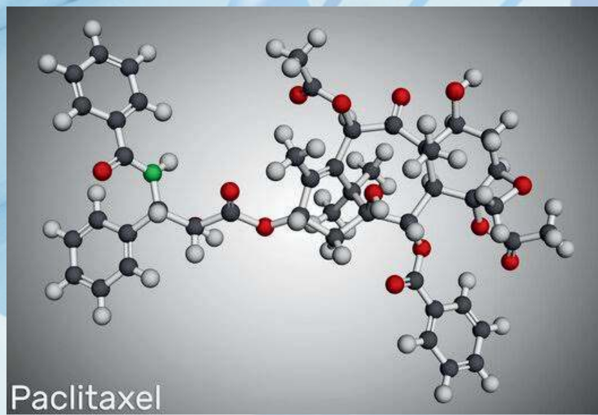
What is anti-cancer agent?

An anticancer agent, also known as an antineoplastic agent or chemotherapeutic drug, is a medication used to treat cancer by destroying, shrinking, or slowing the growth of cancer cells.

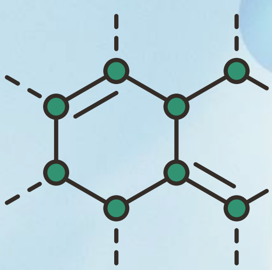
PACLITAXEL :

Paclitaxel, an anticancer drug from natural resource, also known as **Taxol**, is a diterpenoid. It was first isolated from the bark of pacific yew tree (**Taxus brevifolia**). The paclitaxel molecule consists of a tetracyclic core called baccatin III and an amide tail. The core rings are conveniently called (from left to right) ring A (a cyclohexene), ring B (a cyclooctane), ring C (a cyclohexane) and ring D (an oxetane).



Use of Paclitaxel as a drug :

Paclitaxel was approved by the U. S Food and Drug Administration (FDA) for treatment of drug -resistant ovarian and breast cancer and also is used in treatment of Kaposi's sarcoma and Lung cancer. Paclitaxel work by stabilizing microtubule, thus inhibit mitosis. The cell ar unable to multiply and thus tumor are unable to grow.



Action Mechanism :

Microtubules are dynamic cytoskeletal structures composed of tubulin protein subunits. Paclitaxel functions by binding to the β-tubulin subunits within microtubules. Specifically, paclitaxel binds to the inner surface of microtubules in proximity to the nucleotide-binding site on β-tubulin. This binding promotes the assembly of tubulin subunits into stable, non-dynamic microtubules, effectively impeding their typical disassembly or depolymerization. By stabilizing microtubules, paclitaxel disrupts the dynamic equilibrium of microtubule assembly and disassembly, a critical process for the formation and functionality of the mitotic spindle. As a result, the spindle apparatus cannot properly.segregate chromosomes during mitosis.

The disruption of proper spindle function triggers a cell cycle checkpoint response, primarily activating the spindle assembly checkpoint (SAC) within the cell cycle. In the presence of paclitaxel, the SAC detects anomalies in the spindle formation caused by the stabilized microtubules. This detection results in the cell cycle arrest at the G2/M phase, effectively preventing the cell from advancing into mitosis.

Prolonged arrest in the G2/M phase activates cellular signaling pathways that promote apoptosis.

Did You Know?

The global paclitaxel injection market size is calculated at USD 7.01 billion in 2025 and is forecasted to reach around USD 17.52 billion by 2034, accelerating at a CAGR of 12.30% from 2025 to 2034. The North America paclitaxel injection market size surpassed USD 2.50 billion in 2024 and is expanding at a CAGR of 10.98% during the forecast period. The market sizing and forecasts are revenue-based (USD Million/Billion), with 2024 as the base year.

Synthesis and Research on Paclitaxel :

Synthetic chemists in the U.S. and France had been interested in paclitaxel, beginning in the late 1970s. As noted, by 1992 extensive efforts were underway to accomplish the total synthesis of paclitaxel, efforts motivated by the desire to generate new chemical understanding rather than to achieve practical commercial production. In contrast, the French group of Pierre Potier at the Centre national de la recherche scientifique (CNRS) addressed the matter of overall process yield, showing that it was feasible to isolate relatively large quantities of the compound 10-deacetylbaccatin from the European yew, Taxus baccata, which grew on the CNRS campus and whose needles were available in large quantity. By virtue of its structure, 10-deacetylbaccatin was seen as a viable starting material for a short semisynthesis to produce paclitaxel. By 1988, Poitier and collaborators had published a semisynthetic route from needles of the European yew to paclitaxel.

Undisturbed Pacific yew bark contains paclitaxel and related chemicals.

The view of the NCI, however, was that even this route was not practical. The group of Robert A. Holton had also pursued a practical semisynthetic production route; by late 1989, Holton's group had developed a semisynthetic route to paclitaxel with twice the yield of the Potier process. The main innovation was "Ojima–Holton coupling", a ring-opening method independently discovered by Holton and Ojima. Florida State University, where Holton worked, signed a deal with Bristol-Myers Squibb (BMS) to license their semisynthesis and future patents. In 1992, Holton patented an improved process with an 80% yield, and BMS took the process in-house and started to manufacture paclitaxel in Ireland from 10-deacetylbaccatin isolated from the needles of the European yew. In early 1993, BMS announced that it would cease reliance on Pacific yew bark by the end of 1995, effectively terminating ecological controversy over its use. This announcement also made good their commitment to develop an alternative supply route, made to the NCI in their cooperative research and development agreement (CRADA) application of 1989.

As of 2013, BMS was using the semisynthetic method utilizing needles from the European yew to produce paclitaxel. Another company which worked with BMS until 2012,Phyton Biotech, Inc., uses plant cell fermentation (PCF) technology.By cultivating a specific Taxus cell line in fermentation tanks, they no longer need ongoing sourcing of material from actual yew tree plantations. Paclitaxel is then captured directly from the suspension broth by a resin allowing concentration to highly enriched powder containing about 40% paclitaxel. The compound is then purified by one chromatographic step followed by crystallization.Compared to the semisynthesis method, PCF eliminates the need for many hazardous chemicals and saves a considerable amount of energy.

Conclusion :

Though there are several side effect of paclitaxel, it is successful in chemotherapy. The estimated 5-year survival rates were 76.9% for the group receiving paclitaxel every 3 weeks, 81.5% for the group receiving weekly paclitaxel, 81.2% for the group receiving docetaxel every 3 weeks, and 77.6% for the group receiving weekly docetaxel. The future scope of paclitaxel research and development focuses on improving its delivery, addressing limitations in current formulations, and exploring its potential for treating non-cancerous conditions, with nanotechnology playing a key role.

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> **Learning gives you creativity , creativity leads to thinking , thinking provides knowledge and knowledge makes you great .**
>
> **~ Dr. A.P.J. Abdul Kalam**

THE CHEMISTRY OF SUNSCREEN:

How they Protect Us

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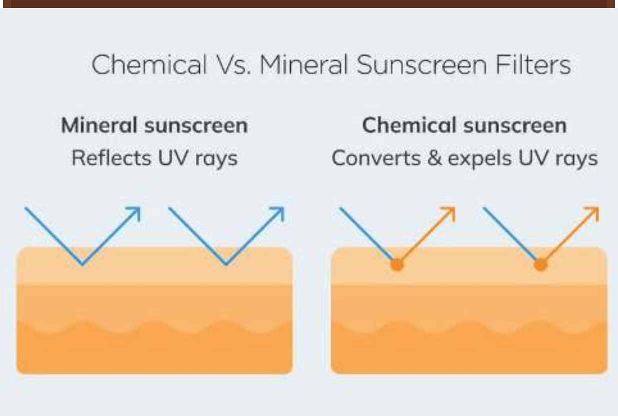
Sunshine – it's warm, inviting, and the ultimate mood booster. But don't be fooled. Behind the golden glow, a silent war rages on your skin. UV rays? They are like invisible draggers, slicing through your skin's defences, fast-tracking wrinkles, dark spots, and in the worst case, skin cancer.

This is where sunscreen steps in, not just as a beauty essential, but a non-negotiable armour. It's not about avoiding a tan; it's it's about outsmarting the sun's long-term damage. And in a tropical country like India, where the sun blazes almost year-round, SPF isn't just a summer thing, it's an everyday must. The question is, how does this bottled magic work? Is SPF 50 really leagues ahead of SPF 30, or is it just clever marketing? and what's the difference between a sunscreen that blocks and one that absorbs UV rays?



We're about to break down the chemistry of sunscreen, minus the dull textbook explanations, so you can protect your skin like someone who knows their science and makes smart choices in this economy.

But before we jump onto the topic of sunscreen, let us know what we are dealing with, those hidden golden rays of the sun are ultraviolet waves, and trust me, they are not here to play nice. These sneaky beams are split into three categories:

UVA – The silent agers. They dive deep into your skin, wrecking collagen and fast-tracking wrinkles like an overachiever on a mission. Worst part? They are around all year, even on cloudy days. Next time think twice before skipping sunscreen on a cool cloudy day.

UVB – The fiery culprits. These rays don't bother going deep – they hit the surface, causing those red spots, tanning, blistering, and painful sunburns. Oh, and they are also linked to skin cancer, so yeah, not the best company.

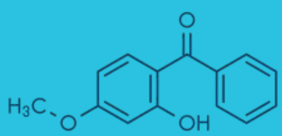
UVC – The outcast. Luckily, the ozone layer filters these out before they reach us. Small win.

Chemical Sunscreens – The Absorber

The common ingredients used in these sunscreens are:

Avobenzone : Absorbs UVB and UVA rays to protect the skin from sun damage but is unstable in sunlight and needs a stabilizer like octocrylene.

Oxybenzone : A synthetic chemical from the benzophenone group, used as a UV filter. It can cause skin irritation in sensitive individuals and is linked to coral reef damage. Many brands are phasing it out.



oxybenzone

Octinoxate : shields against UVB rays to prevent sunburn. They too break down under sun exposure and may require stabilizers.

Octisalate : Absorbs UV rays and enhances water resistance. They soften the sunscreen texture, making it more spreadable.

All these ingredients are absorbed into the skin and react with UV radiation, converting the energy into heat and dispersing it, thus preventing the UV rays from damaging the skin. Unlike physical filters, chemical filters need 15 to 20 minutes to activate, as they must absorb into the skin before they start working.

Physical (Mineral) Sunscreens – The Shield

Think of these as your skin's armour. These sunscreens act as physical barriers, reflecting and scattering UV rays away from the skin, which uses only inorganic compounds (zinc oxide and/or titanium dioxide) as active ingredients.

Zinc Oxide is a natural mineral that provides broad-spectrum against both UVA and UVB wavelengths. They may also have anti-inflammatory properties, making them suitable for sensitive or reactive skin. At the same time, Titanium Oxide is another natural mineral that provides strong UVB protection and is primarily responsible for sunburns. They are often used in sunscreen formulations to help create a lightweight texture and minimize excess oil. Both compounds are extremely stable under sunlight and don't require any stabilizer making physical sunscreens more reliable. Modern formulations use nano-sized particles to reduce the thick white cast while maintaining efficiency.

Photostability and Degradation: Why some sunscreens fail ?

The photo-stability of the sunscreens varies from each other. Photostability is how well a sunscreen maintains effectiveness when exposed to sunlight. Some chemical UV filters degrade in the sun and become less effective over time, which is why, many sunscreens combine multiple filters to stabilize each other and some brands use encapsulation technology to slow down degradation.

Avobenzone degrades quickly, reducing UVA protection, unless paired with stabilizers like Octocrylene or Tinosorb. Octinoxate and Oxybenzone also degrade but can be stabilized by antioxidants like Vitamin E or Ferulic Acid. Mineral sunscreens (Zinc Oxide & Titanium Dioxide) are naturally stable but may be enhanced with coatings to prevent clumping. To prevent photodegradation, broad-spectrum sunscreens are formulated with a mix of UV filters, stabilizers, and antioxidants for long-lasting protection.

Sunscreen Formulation and Delivery system: The science of texture

A sunscreen's effectiveness isn't just about UV filters—it's also about how they are delivered into the skin for maximum protection.

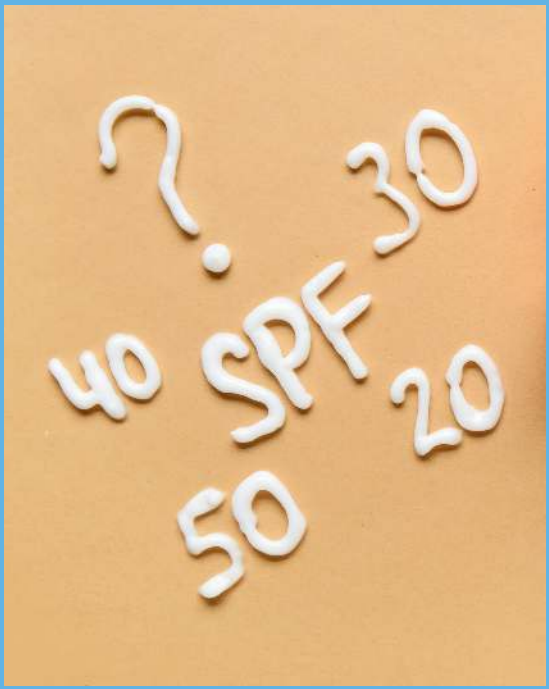
Encapsulation Technology – Some modern sunscreens encapsulate UV filters in microspheres or liposomes, improving stability and reducing irritation.

Emulsifiers & Solvents – Help dissolve UV filters and create a smooth, non-greasy feel. Common emulsifiers include lecithin and glyceryl stearate.

Water-Resistant Polymers – Sunscreens labelled water-resistant (80 min) contain film-forming agents like silicones and acrylates, which help prevent sweat and water from washing away the product.

Antioxidants (Vitamin C, Vitamin E, Niacinamide) – Many sunscreens now include antioxidants to neutralize free radicals formed from UV exposure, adding extra protection against skin ageing.

Ever picked up sunscreen and felt lost staring at the SPF 50+ PA++++ label? What do these numbers mean? Are they just marketing gimmicks, or do they determine how well you're protected from the sun? Let's break it down so you never have to guess again.



SPF (Sun Protection Factor) is like a timer for how long you can stay in the sun without burning. It must be noted that SPF talks about protection against UVB only and not UVA. In simple terms, if your skin normally burns in 10 minutes, SPF 30 theoretically extends that to 300 minutes (30 times longer). An SPF 15 sunscreen will take 15 times for your skin to burn.

- **SPF 15** → Blocks 93% of UVB rays
- **SPF 30** → Blocks 97% of UVB rays
- **SPF 50** → Blocks 98% of UVB rays
- **SPF 100** → Blocks 99% of UVB rays (but still needs reapplication!)

Higher SPF ≠ Exponential Protection! The difference between SPF 30 and SPF 50 is just 1% more coverage, so don't fall for the "**higher is always better**" trap. Sunscreen breaks down in the sun, so reapplication is key. For continuous protection, apply sunscreen every two hours.

We're about to break down the chemistry of sunscreen, minus the dull textbook explanations, so you can protect your skin like someone who knows their science and makes smart choices in this economy.

While SPF focuses on UVB rays (which cause burns), **the PA system** tells you how well your sunscreen shields against UVA rays—the ones responsible for wrinkles, dark spots, and deeper skin damage.

PA+ : Sunscreen with this PA level, offers the lowest UVA protection with a score or PA measurement between 2 and 4.

PA++ : Sunscreen with PA levels ++ offers moderate UVA protection to the skin. They have a PA score or measurement between 4 and 8.

PA+++ : This PA level is considered good, offering a high level of UVA protection. Sunscreen with PA+++ has a score between 8 and 16.

PA++++ : Any sunscreen with PA levels ++++, offers the highest level of UVA protection with a score of more than 16. So if you're serious about anti-aging and preventing hyperpigmentation, a high PA rating is just as important as SPF!

Choosing the right sunscreen isn't just about SPF – it's about photostability, formulation, and compatibility with your skin type. Whether, you prefer lightweight chemical gel, a hydrating hybrid (in case of oily skin) or a gentle mineral-based sunscreen (in case of sensitive, acne pro or dry skin), understanding the chemistry behind these formulations ensures you get the best sun protection possible.

Remember, no sunscreen, no skincare! So find one that suits you, apply it generously, and wear it like your skin depends on it – because it literally does. And when someone compliments your glow-defying skin years down the line? Just smile and say, "It's the sunscreen."

CONCLUSION :

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CHEMISTRY IN SPACE : HOW THE UNIVERSE IS A GIANT LABORATORY

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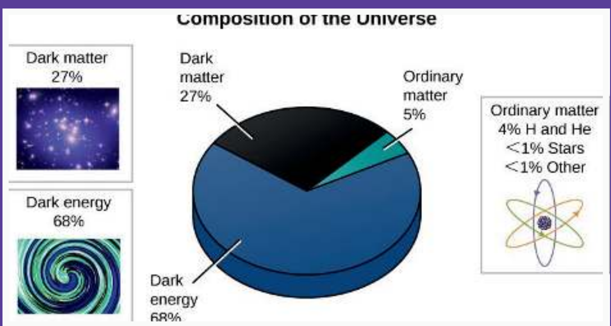
When we think of chemistry, we often picture test tubes, Bunsen burners, and laboratory benches. But the universe itself is the ultimate laboratory, where reactions unfold on cosmic scales, shaping planets, stars, and even life itself. From the formation of molecules in interstellar clouds to complex organic chemistry on distant exoplanets, chemistry plays a crucial role in the evolution of the cosmos.

The Cosmic Origins of Elements

The Big Bang created hydrogen and helium, but heavier elements were forged in stars through nuclear fusion. Supernova explosions spread these elements across space , seeding future planetary systems. The periodic table's elements are essentially " **star dust** " forming everything from planets to living organisms.

Interstellar Chemistry : The Birthplace of Molecules

Deep in cold, dense molecular clouds, atoms combine to form molecules. The most abundant and essential molecule in space is molecular hydrogen (H_2), but more complex molecules such as water (H_2O), ammonia (NH_3), and even simple organic compounds like methane (CH_4) and formaldehyde (CH_2O) have been detected in space.
One of the most fascinating discoveries in recent years is the presence of polycyclic aromatic hydrocarbons (PAHs) in space complex molecules thought to be linked to the origins of life. These molecules form in the outflows of dying stars and are spread throughout the galaxy, potentially seeding young planetary systems with organic matter.



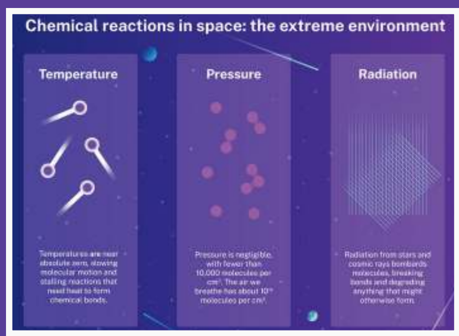
Chemistry on Planets and Moons

Planets and their moons act as specialized chemical reactors, where atmospheric and geological processes drive complex chemistry.

Mars : Scientists have detected organic molecules and methane on Mars, suggesting potential biological or geological activity.

Europa & Enceladus : These icy moons of Jupiter and Saturn have subsurface oceans, where hydrothermal vents might support chemistry similar to that of Earth's deep-sea vents, possibly fostering life.

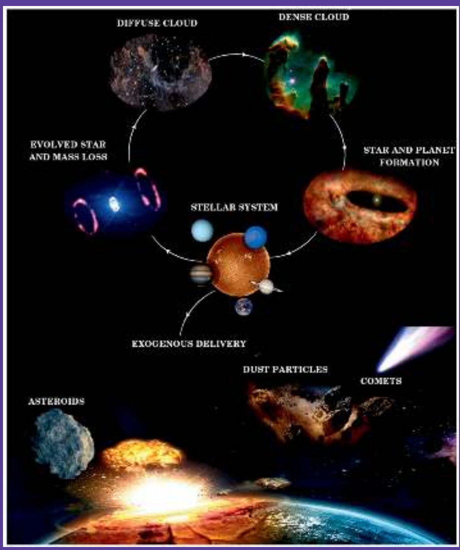
Titan : Saturn's largest moon has a thick atmosphere rich in nitrogen and methane, with complex organic chemistry occurring in its hazy skies and lakes of liquid hydrocarbons.



Astrochemistry and the Search for Life

One of the most exciting frontiers in chemistry is astrobiology — the study of how chemistry in space might lead to life. Scientists search for biosignatures, such as oxygen, methane, and other gases that could indicate biological activity, on exoplanets orbiting distant stars. The discovery of phosphine in Venus' atmosphere, for example, sparked interest because it could be produced by unknown chemical processes — or even microbial life.

The universe is a living, evolving chemistry lab, constantly generating new elements, molecules, and conditions for life.Studying space chemistry helps us understand our origins, search for extraterrestrial life, and prepare for interplanetary exploration.
exploration.



Did you know?

Scientists believe that intense pressure inside Neptune and Uranus turns carbon into diamonds, which then rain down towards the planets' cores. This happens due to extreme heat and pressure breaking down methane (CH_4) into carbon, which crystallizes into carbon , which crystallizes into diamonds.

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India enters a new orbit
Wishing
Group Captain
Shubhanshu Shukla
a successsful space mission ,
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Behind the Cold Door

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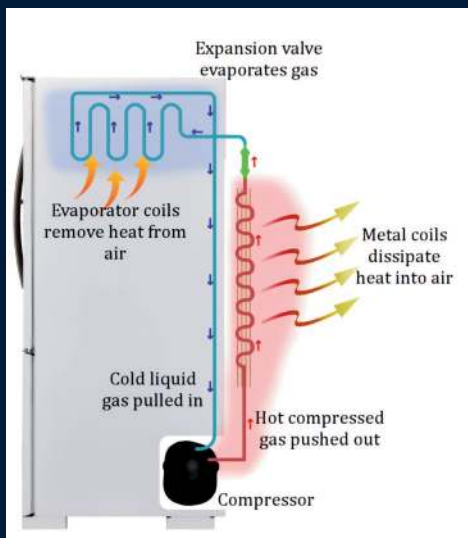
Back in the old days, in a world where keeping food fresh was a challenge, humans invented a magical box called the refrigerator. This box didn't just keep food cold; it used the power of chemistry and physics to defy nature itself. At the heart of this invention was a special substance called a refrigerant, a chemical with the unique ability to change between liquid and gas at low temperatures. This refrigerant was the hero of the story, making the impossible possible.

"The Magical Elixer" Refrigerant Deep within Frosty's veins flowed a mystical potion called the refrigerant. This special liquid had an amazing ability—it could change from liquid to gas at very low temperatures! Unlike water, which needed a hot stove to boil, the refrigerant could turn into gas just by absorbing a little heat. But not just any liquid could do this! Frosty needed a stable, non-toxic, and environmentally friendly refrigerant to keep his magic running. In the past, old refrigerators used CFCs (Chlorofluorocarbons), but they were troublemakers, harming the Earth's protective ozone layer. So, wise scientists replaced them with new, eco-friendly refrigerants like R-134a.

What is the chemistry behind Refrigerator ?

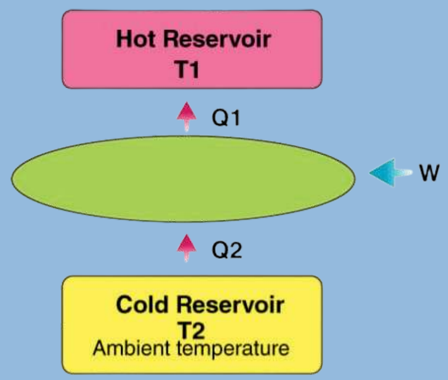
The Chemistry behind the Refrigerator involves the phase change of a refrigerant, driven by pressure and temperature changes . The refrigerant absorbs heat from insides the fridge (Colling the interior) and releases it out side, maintaining a cold environment. This process is a practical application of thermodynamics and heat transfer principals .



Working method of Heat pump :

The refrigerant moves in a continuous cycle within a closed loop, transforming repeatedly to keep the refrigerator cool. It begins in the **compressor**, where it is compressed, raising its temperature and pressure. The hot, high-pressure gas then moves to the **condenser**, where it releases heat to the surroundings and turns into a high-pressure liquid. This liquid then passes through the **expansion valve**, which reduces its pressure, making it a cold, low-pressure mixture. The refrigerant then enters the **evaporator**, where it absorbs heat from inside the refrigerator, cooling the food and air. As it absorbs heat, it evaporates back into a gas, completing the cycle and maintaining a cool interior.

But the story didn't end there. The refrigerant, now a gas again, returned to the compressor to begin the cycle anew. This endless loop was powered by the laws of thermodynamics, the rules that govern energy and heat. The **first law of thermodynamics** ensured that energy was conserved.



Mathematically : $Q_{in} + W = Q_{out}$

The heat absorbed from inside the fridge, plus the work done by the compressor, equaled the heat released outside. The **second law of thermodynamics** explained why this process required effort. Heat naturally flows from hot to cold, but the refrigerator reversed this flow, moving heat from a cold place to a hot one.

Mathematically : $C_{OP} = Q_{in} / W$

This defiance of nature required energy, measured by the **Coefficient of performance (COP)**, which told us how efficient the refrigerator was.

The refrigerant itself was a carefully chosen chemical, often a hydrofluorocarbon like R-134a. It had to be stable, non-toxic, and environmentally friendly. Older refrigerants, like chlorofluorocarbons (CFCs), were once used but were later banned because they harmed the ozone layer. Modern refrigerants were designed to be kinder to the planet, balancing efficiency with safety.

The refrigerator was more than just a machine; it was a testament to human ingenuity. By harnessing the chemistry of phase changes and the physics of heat transfer, it created a cold oasis in a warm world. Every time you open your fridge, remember the incredible journey of the refrigerant, the unsung hero that keeps your food fresh and your drinks cold. And so, the cycle continues, a never-ending dance of science and engineering, making life a little cooler for us all.

FACTS

R-134a contributes to global warming and health risks. Industries are moving toward low-GWP alternatives like HFO-1234yf for sustainability.

Freon-134a (C_2H_2F4) is an HFC refrigerant that replaced CFCs like Freon-12. Although it does not harm the ozone layer, it has environmental and health risks.

Environmental : A potent greenhouse gas with a GWP ~1,300 times CO2, lasting 14 years in the atmosphere. It undergoes photodissociation, releasing fluorinated radicals.

Health & Safety : At high temperatures (>500°C), it decomposes into toxic gases like HF and COF2, which can harm the lungs and eyes. High concentrations can also displace oxygen, causing dizziness and cardiac risks. I

Industrial Risks : Stored under pressure, it can cause frostbite, rupture hazards, and polymer degradation in

BIOMIMICRY AND NATURE-INSPIRED CHEMISTRY: UNLOCKING NATURE'S BLUEPRINT

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In the quest for innovation, nature has always been a master chemist. From the iridescence of a butterfly's wing to the self-cleaning properties of a lotus leaf, the natural world has provided scientists with inspiration for centuries. Today, biomimicry — the practice of emulating nature's designs and processes — is transforming the field of chemistry, leading to sustainable, efficient, and ground-breaking solutions.

Currently, terms such as bioinspiration, biomimicry, biomimetics, nature inspiration, and nature mimicry are often used synonymously in the literature. In this context, words with "nature" prefixes capture the broad ecosystem of living and non-living natural systems, and words with "bio" prefixes are associated only with living natural organisms (biology) and are contained within the broad spectrum of nature.

NATURE AS A CHEMICAL INNOVATOR

Take the humble spider. Its silk is stronger than steel by weight and tougher than Kevlar, yet it is spun at ambient temperature from water-soluble proteins. Mimicking this process, chemists are developing bio-inspired fibres and polymers without the need for extreme temperatures or toxic solvents.

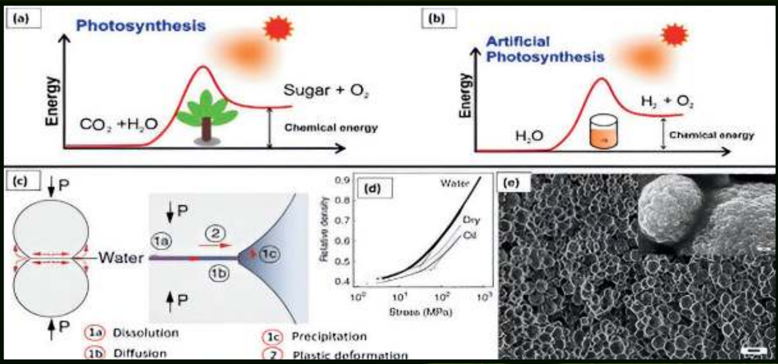
Similarly, nacre (mother-of-pearl) inspires the design of advanced composites with exceptional mechanical properties and lightweight structures.

Photosynthesis is another marvel. Plants efficiently convert sunlight, water, and carbon dioxide into carbohydrates and oxygen. Inspired by this, chemists are working on artificial photosynthesis systems that aim to produce clean fuels, such as hydrogen, directly from sunlight — a promising step toward renewable energy.

NATURE-INSPIRED PROCESSES

Nature-inspired processes are artificial processes which enable the emulation of a certain natural process such as photosynthesis. An artificial photosynthesis process can therefore be used to harvest solar energy or for solar-to-fuel conversion. A nature-inspired process in this case is triggered by the observation of photosynthesis of plant/tree leaves (storing energy in the form of chemical bonds). Recently, many systems have been developed to harvest solar energy, such as a system having flower-like nanostructures generated from copper phosphate nanocomposites, in which TiO_2 nanoparticles were incorporated over the petals of a flower (or copper phosphate nanosheets). The copper phosphate flower provides a large surface area to bind TiO_2 nanoparticles, whereby the TiO_2 nanoparticles act as photocatalysts. Therefore, a copper phosphate flower functionalized with TiO_2 nanoparticles works as a solar light harvesting device. This system works as an antenna for solar light absorption and spli

TURN OVER

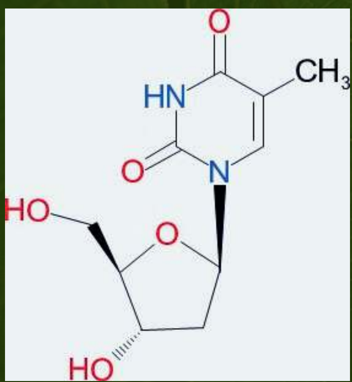


[a] Natural photosynthesis vs [b] artificial photosynthesis or nature-inspired photosynthesis , [c] artificial bio-mineralization four-stage process , [d] achieved density in different media , [e] SEM image, morphology of artificial bio-mineralized ceramic

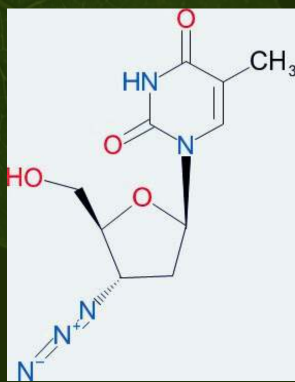
Rhodopsin, a light-sensitive protein found in rod photoreceptor cells of the retina, is crucial for vision in low light conditions. It consists of opsin (a protein) and 11-cis-retinal (a light-sensitive chromophore). Optical sensors mimicking the retina's rhodopsin are developed by chemically synthesizing retinyl Schiff base (RSB) complexes that mimic the natural rhodopsin-like protein, offering advantages like stability and designability for photon detection.

BIOIMITATION IN DRUGS

It is a well-known fact that AIDS (Acquired immune deficiency syndrome) is caused by HIV (Human immunodeficiency virus) was treated with AZT (azidothymidine), an anti-viral drug with some success. These drugs imitate natural nucleosides (e.g., AZT imitates deoxythymidine) and inhibit the virus from copying its RNA into DNA inside human cells by inhibiting the reverse transcriptase enzyme.



(Deoxythymidine : a nucleoside of DNA)



(Azidothymidine : Anti-AIDS drug)

THE ESSENCE OF BIOMIMICRY

Biomimicry goes beyond mere imitation. It is the conscious application of nature’s strategies to solve human challenges. Nature operates with remarkable efficiency, using simple materials, mild conditions, and renewable energy to produce complex structures and functions. Chemistry inspired by these biological processes opens the door to eco-friendly technologies, novel materials, and innovative synthetic pathways.

GREEN CHEMISTRY AND SUSTAINABLE PRACTICES

Biomimicry naturally aligns with the principles of green chemistry. By studying how organisms manage waste, recycle materials, and catalyze reactions, chemists are designing processes that minimize environmental impact. For example, enzymes — nature's catalysts — often function under mild conditions and with remarkable specificity, reducing energy consumption and unwanted by-products. This has led to the rise of biocatalysis in pharmaceuticals , food processing , and fine chemical production. Nanozymes (Nanomaterials with enzyme-like catalytic activities exhibiting unique features of stability and multifunctionality) and fullerene nanocatalysts (multifunctional self-assembled nanostructures that can mimic enzyme activity) are some artificial enzymes or synzymes.

CHALLENGES AND OPPORTUNITIES

While nature offers elegant solutions, translating them into scalable technologies is not always straightforward. Complex structures, intricate self-assembly, and highly specific interactions found in biological systems are often difficult to replicate fully. However, advances in nanotechnology, materials science, and synthetic biology are rapidly overcoming these challenges.

THE FUTURE OF BIOMIMETIC CHEMISTRY

As chemists continue to draw inspiration from nature, the future promises materials that self heal like human skin, surfaces that repel dirt like lotus leaves, and energy systems that mimic the efficiency of photosynthesis. The synergy of biomimicry and chemistry not only leads to technological innovations but also fosters a more sustainable relationship with the planet.

In essence, biomimicry teaches us that nature is not just a model but also a mentor. By listening to nature's wisdom, chemists are unlocking a world of possibilities that could redefine the boundaries of science and technology. Ag

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HOW CHEMISTRY IS USED IN CRIME INVESTIGATION (FORENSIC CHEMISTRY)

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Forensic chemistry applies chemical analysis to crime scene evidence, helping law enforcement solve cases with scientific accuracy. From detecting drugs to analysing fingerprints, forensic chemistry plays a crucial role in criminal investigations.

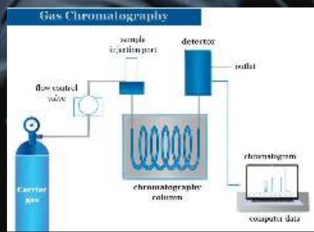
THE ROLE OF FORENSIC CHEMISTRY IN CRIME INVESTIGATION :

Forensic chemists analyse physical evidence, such as blood, poisons, drugs, explosives, and gunshot residues, to uncover the truth behind crimes. Their findings help determine causes of death, confirm the presence of illegal substances, and even reconstruct crime scenes. Courts rely on forensic reports as scientific proof, making forensic chemistry a key pillar in the justice system.

COMMON TECHNIQUES IN FORENSIC CHEMISTRY :

A. Chromatography – Separating Chemical Components :

Chromatography is widely used to separate and identify substances in complex mixtures. It is crucial for drug testing, poison detection, and explosive analysis.



Gas Chromatography (GC) : Used to analyse volatile compounds like alcohol in a driver's breath, explosive residues, and illicit drugs. It works by separating components based on their boiling points and interaction with a stationary phase.

Thin-Layer Chromatography (TLC) : A simple and quick technique used to detect drugs, dyes, and inks in forensic cases. It involves applying a sample on a plate coated with silica gel, which separates substances based on their affinity to the mobile phase.

Liquid Chromatography (LC) : Helps detect toxins, drugs, and biochemical markers in blood, urine, and food samples. High Performance Liquid Chromatography (HPLC) is particularly useful in detecting trace amounts of poisons.

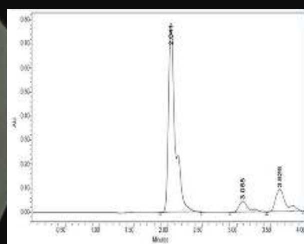


Figure 1 : HPLC readout of an Excedrin tablet. Peaks from left to right are acetaminophen, aspirin, and caffeine.

B. Toxicology and Drug Analysis – Detecting Poisons and Drugs :

Forensic toxicology involves analysing biological samples (blood, urine, stomach contents) to detect drugs, poisons, or toxins. It is widely used in cases of drug overdoses, poisoning, and substance abuse.

Immunoassay Tests : Rapid screening methods used to detect drugs in body fluids. They are commonly used in workplace drug testing and post – mortem toxicology.

Gas Chromatography - Mass Spectrometry (GC-MS) : Provides precise identification of drugs and poisons. It is considered the gold standard for forensic toxicology.

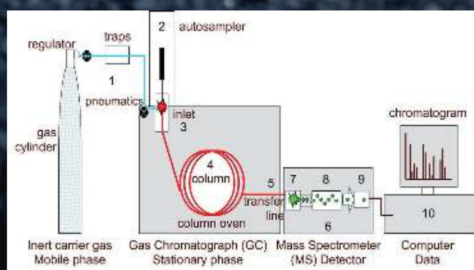


Figure 2 : Gas Chromatography-Mass Spectrometry (GC MS)

C. Spectroscopy – Identifying Chemical Structures :

Spectroscopy techniques analyse how substances interact with electromagnetic radiation, allowing forensic chemists to determine chemical compositions and molecular structures.

Infrared (IR) Spectroscopy : Identifies chemical bonds in substances like fibres, paints, explosives, and drugs. Every compound has a unique IR spectrum, making it an effective tool for substance identification.

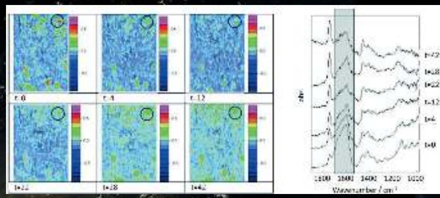


Figure 3 : Infrared (IR) Spectroscopy graph

UV-Visible Spectroscopy : Used to detect dyes, bloodstains, and biological fluids. It helps confirm the presence of drugs in toxicology tests and determine the age of ink on documents.

FTIR (Fourier Transform Infrared) spectroscopy : A technique used to analyse the molecular composition of a sample by measuring its absorption of infrared light. It provides a unique fingerprint of the sample, identifying functional groups and chemical bonds.

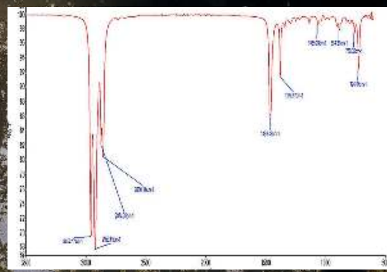


Figure 4 : ATR FTIR spectrum for hexane showing percent transmittance (%T) versus wavenumber (cm-1)

D. Fingerprint Analysis – Chemical Methods to Develop Prints :

Fingerprints are unique to individuals and are critical in crime investigations. Some surfaces, such as glass, plastic, and paper, require chemical techniques to visualize fingerprints.

Ninhydrin Test : A chemical reagent that reacts with amino acids in sweat, producing a purple colour that makes fingerprints visible on paper and porous surfaces.

Superglue Fuming (Cyanoacrylate Fuming) : Used to develop prints on non – porous surfaces like glass, metal, and plastic. The fumes from cyanoacrylate glue react with fingerprint residues, forming a white, visible impression.

Silver Nitrate Test : Used on porous materials like paper. Silver nitrate reacts with salt in sweat, producing a dark print when exposed to UV light.

COMMON TECHNIQUES IN FORENSIC CHEMISTRY :

Forensic chemistry has been instrumental in solving many high-profile criminal cases worldwide.

Murder Investigations : Blood analysis, DNA testing, and gunshot residue testing help confirm a suspect's involvement.

Drug Trafficking Cases : Seized drugs are analysed to determine their purity, composition, and source.

Forgery Detection : Ink and paper analysis reveal document alterations and counterfeit materials.

Arson Investigations : Chemical analysis of burnt materials helps identify accelerants used to start fires.

FUTURE OF FORENSIC CHEMISTRY :

The future of forensic chemistry is advancing with the integration of cutting-edge technologies such as artificial intelligence, nanotechnology, and advanced spectroscopy techniques. Current research focuses on improving the sensitivity and accuracy of detecting trace evidence, developing rapid on-site testing methods, and enhancing DNA analysis with minimal sample degradation. Efforts are also being made to incorporate machine learning for data analysis and pattern recognition in criminal investigations. As forensic chemistry evolves, it promises to deliver faster, more precise, and reliable results, ultimately strengthening the justice system.

CONCLUSION :

Forensic chemistry is an essential discipline in criminal investigations, applying chemical principles to analyse substances such as drugs, toxins, explosives, and trace evidence. By providing precise scientific data, forensic chemists contribute to the accurate reconstruction of events and the administration of justice. Their work is integral to both criminal prosecution and defence, ensuring the reliability and integrity of forensic evidence in legal contexts.

CONCLUSION :

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> **The excellence of chemistry consists in the experiments by which we learn the secret of nature.**
>
> **~ Robert Boyle [Father of Modern Chenistry]**

Acid-Base Reactions in Cooking

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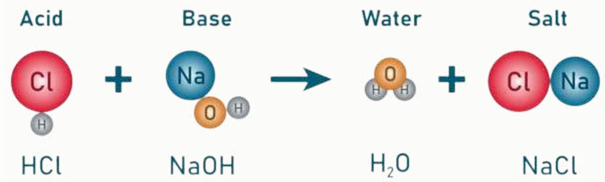
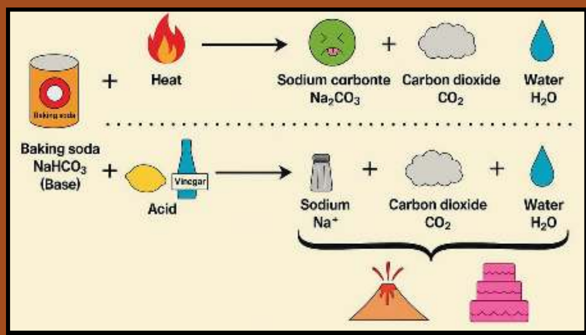
Acid-base reactions are essential to many cooking processes, influencing flavour, texture, and even food preservation. These reactions occur when acidic and basic ingredients interact, often releasing carbon dioxide gas or neutralizing each other.



1 How Cakes and Breads Rise

Baking soda (sodium bicarbonate, $NaHCO_3$) reacts with acidic ingredients like vinegar, buttermilk, or lemon juice to produce carbon dioxide (CO_2) gas. The gas forms bubbles in the dough or batter, making baked goods light and fluffy.



Example reaction :

$$2NaHCO_3 + 2H^+ \rightarrow 2Na^+ + H_2O + CO_2$$

2 Neutralizing Bitterness

Some foods have bitter flavours due to alkaline compounds. Adding an acid, such as lemon juice or vinegar, helps balance the taste and improve the overall flavour profile.

③ Tenderizing Effects

Acids help soften or "**denature**" proteins, making food more tender.

Ceviche : In this dish, raw fish is "cooked" in lime juice. The acid breaks down proteins, changing the fish's texture and making it opaque, similar to the effect of heat.

Marinades for Meat : Tough cuts of meat are often soaked in acidic marinades (vinegar, lemon juice, tomato juice) to help tenderize them and enhance flavour. While acids mainly affect the surface, piercing the meat allows better penetration of flavours.

④ Food Preservation : Pickling & Fermentation

Pickling : Vegetables like cucumbers and onions are preserved by submerging them in a vinegar (acetic acid) solution, which lowers the pH and inhibits bacterial growth. This process not only extends shelf life but also enhances the taste.

Fermentation : Certain bacteria and yeasts produce acids (such as lactic acid) during fermentation, lowering the pH of foods like yogurt, sauerkraut, and kimchi. This natural process extends shelf life and develops probiotics, benefiting gut health.

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From Bean to Brain : The Chemistry of Chocolate Cravings

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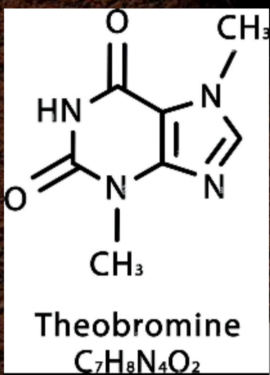
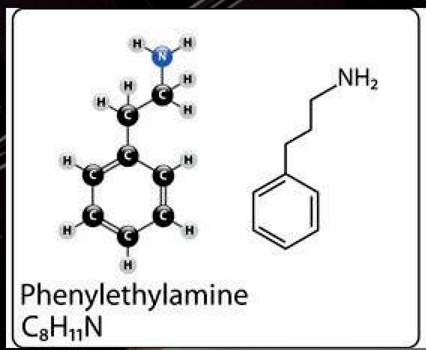
The Chemistry in Chocolate : Why It Tastes So Good ?

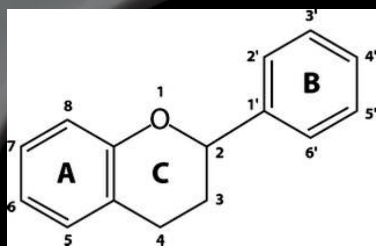
Chocolate isn't just a delicious treat — it's a fascinating mixture of complex chemicals that affect our taste buds, brain, and even mood.

At the heart of chocolate is **Cocoa solids**, which contain a variety of compounds. One key chemical is **theobromine**, a stimulant similar to caffeine that contributes to chocolate's energizing effect. Another is **phenylethylamine (PEA)**, often called the "**love chemical**," because it's associated with the release of feel-good endorphins in the brain.





Chocolate also contains **flavonoids, natural antioxidants** that may help protect cells and improve blood flow. These compounds are especially abundant in dark chocolate, which is considered healthier due to its higher cocoa content.



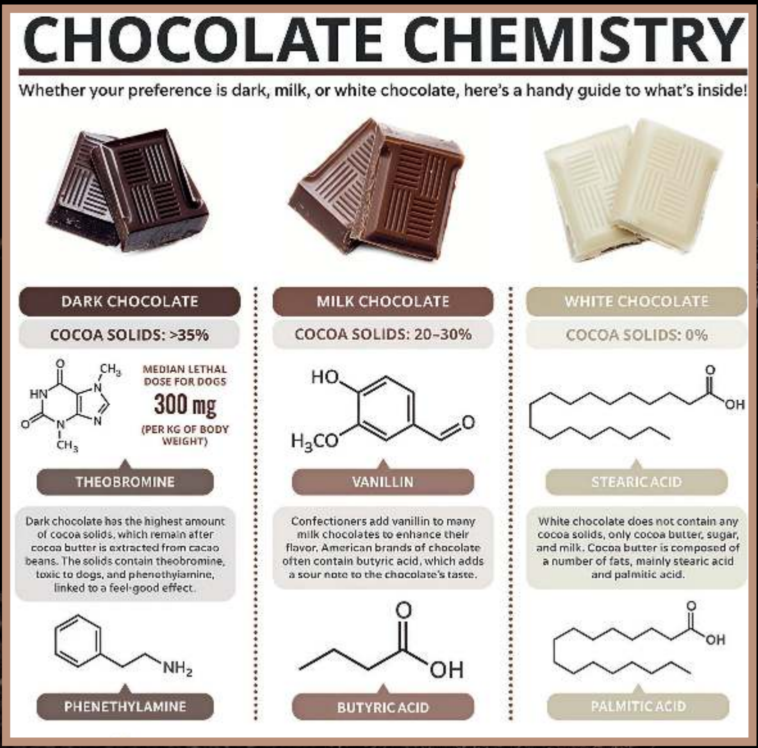
And let's not forget the **Maillard reaction**, a chemical reaction between **amino acids** and **sugars** that happens during roasting of cocoa beans. It creates the rich aroma and complex flavor notes in chocolate.

Role in Chocolate Production :

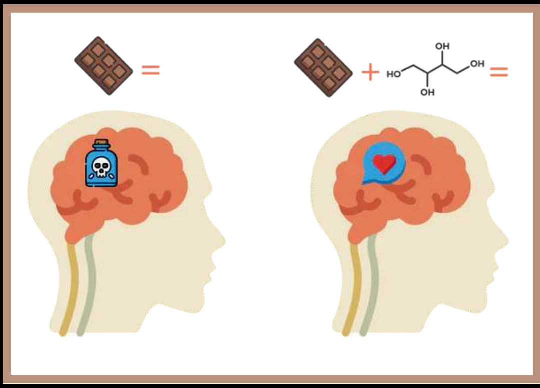
In chocolate making, cocoa beans are roasted at high temperatures (120-140°C). This heat initiates the Maillard reaction, transforming the flavor and aroma precursors present in the beans.

In short, every bite of chocolate is a result of chemistry in action — combining compounds that stimulate our senses and deliver both pleasure and science.

Different types of Chocolate and their chemical compounds :



How chocolate affects our brain :



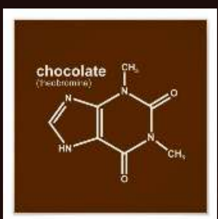
PEA in chocolate mimics feel-good neurotransmitters like dopamine. **Threitol** or sugar alcohols may enhance brain function or neurotransmission.

It emphasizes the neurological chemistry behind chocolate's effects — tying into fields like neurochemistry, nutritional psychology, and functional foods.

DID YOU KNOW ?

1 . The word ' Chocolate ' originates from the Spanish word " chocolate " , which is itself derived from the Nauhatl word " Xocolatl " . It means bitter water .

2 . Why is chocolate toxic to dogs ?



Theobromine is a mild stimulant , similar in effect to caffeine , found in chocolate . This compund is harmless to humans at the levels found in chocolate - a fatal dose would require eating tens of kilograms of milk chocolate !

In cats and dogs , theobromine has a much more potent effect ; small doses can lead to vomiting and diarrhea , whilst as little as 50 gm of dark chocolate could kill a small dog .

CATALYST 2025

Inaguration of Rasayanika 4th Edition & Freshers - Farewell Party
22 July , 2025

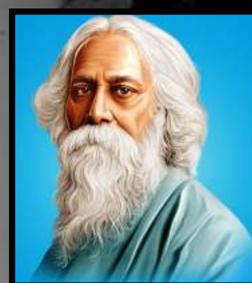
Batch 2022 - 2025

Thank You

A special thanks to the students of Semester II , IV and VI for contributing in fourth edition of RASAYANIKA

" The highest education is that which does not merely give us information but that makes our life in harmony with all existence . "

~ R.N. TAGORE



Presented By ,

Batch 2022 - 2025

Department of Chemistry

Krishnagar Government College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