

THE OCTET

DEPARTMENTAL ANNUAL E-MAGAZINE

EXPLORING MATTER. UNDERSTANDING CHANGE. SHAPING THE FUTURE.

DURGAPUR GOVERNMENT
COLLEGE DEPARTMENT OF
CHEMISTRY PRESENTS:

BEYOND THE ATOM

INSIGHTS, INNOVATIONS,
& RESEARCH



GREEN INNOVATIONS

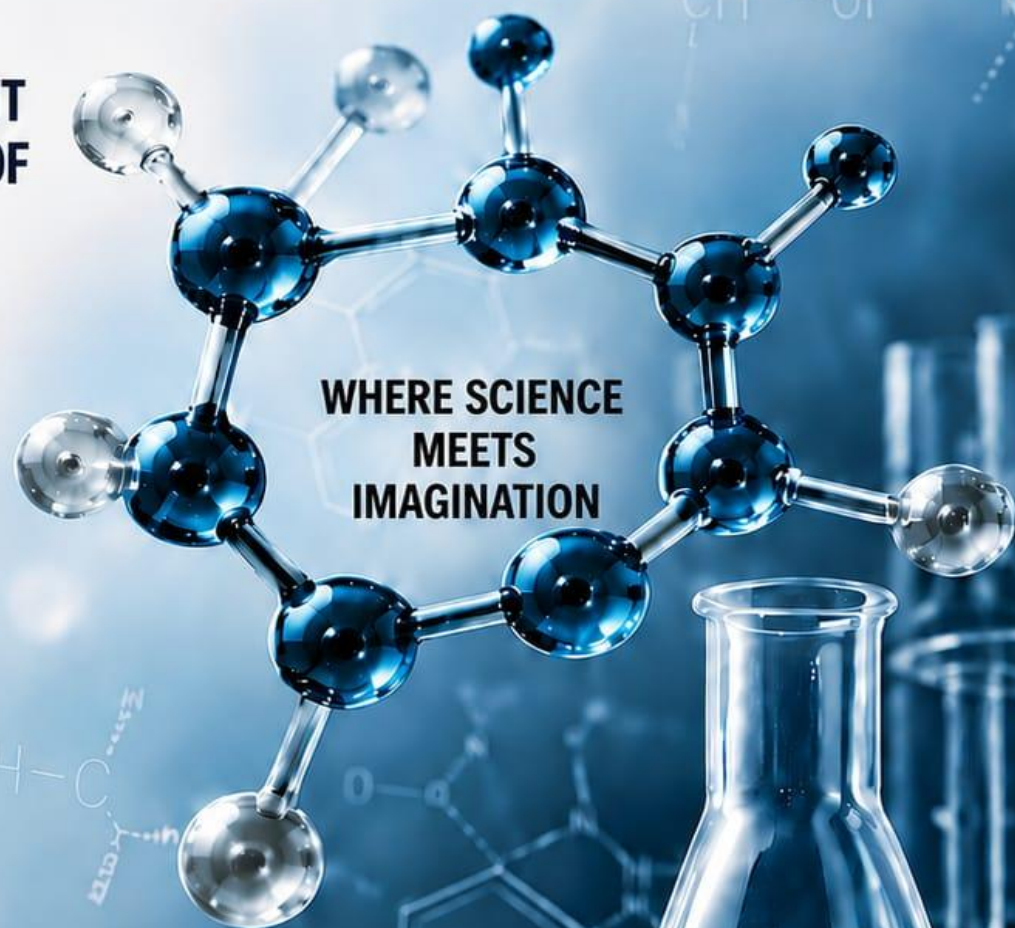


ADVANCED LABS



BEYOND THE ELEMENTS

WHERE SCIENCE
MEETS
IMAGINATION



HONORING THE LEGACY OF **ACHARYA PRAFULLA CHANDRA RAY**

We proudly and reverently dedicate this inaugural edition to the memory of Acharya Prafulla Chandra Ray (P.C. Ray), the revered "Father of Indian Chemistry," on the occasion of his birth anniversary month.

Acharya P.C. Ray was far more than a pioneering scientist. He was a visionary educator, a passionate patriot, and a pathbreaking entrepreneur who founded Bengal Chemicals & Pharmaceuticals—India's first indigenous pharmaceutical company. His groundbreaking discovery of Mercurous Nitrite placed Indian chemical research firmly on the global map. Yet, his true greatness lay in his simplicity and his absolute dedication to nurturing young minds, famously believing that a nation's future depends entirely on the scientific curiosity of its youth.

There could be no better way to begin the journey of our very first magazine than by seeking inspiration from his life and legacy. As students of Durgapur Government College, we pledge to keep his spirit of relentless inquiry, academic excellence, and love for science alive through these pages.

With great honour and respect, we dedicate this maiden edition to the titan of science who taught us that chemistry is a powerful tool to build and transform the world.



ACHARYA P.C RAY

It is a moment of immense pride and joy as the Department of Chemistry at **Durgapur Government College** presents the historic **First Edition** of our departmental magazine. Every journey begins with a single step, and we are thrilled to take our very first step by celebrating the spirit of scientific inquiry and creativity within our student community.

*Welcome to the First Edition of our
Chemistry E-Magazine!*

A MESSAGE FROM DEPARTMENT

Welcome to the inaugural edition of THE OCTET (August 2026), the annual e-magazine of the Department of Chemistry, Durgapur Government College.

Under our central theme, "Beyond the Atom: Insights, Innovations, & Research," this platform celebrates the dynamic intersection where rigorous science meets creative imagination. Our goal is to highlight sustainable green solutions and advanced laboratory breakthroughs emerging in recent days. Dedicated reverently to the enduring legacy of Acharya P.C. Ray, this edition reflects our collective commitment to exploring matter, understanding change, and shaping a better tomorrow through education, innovation, and scientific curiosity.

We extend our warm appreciation to all student contributors, faculty members, and researchers who brought this publication to life.



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CHEMOTHERAPY 2.0

Smarter. Targeted. Personalized.

The Next Era of Cancer Treatment

“The goal is not just to treat cancer, but to transform lives with **science**, **precision** and **hope**.”



INTRODUCTION

For decades, cancer treatment followed a simple rule – destroy the tumor cells – even willing to accept severe systemic toxicity, as the price of cure – often leaving the healthy cells caught in the crossfire. But cancer was never that simple. It could hide, adapt, spread – and sometimes return stronger than before.

What if cancer treatment could do more than just attack?

What happens when medicine learns to aim?—Imagine a tiny therapeutic package travelling through the bloodstream. Millions of cells surrounded it. Yet, instead of attacking every cell in its path, it is designed to recognise and reach the specific cancer cells – delivering its treatment where it is needed most. **“How this possible?”**—But before we explore these possibilities, let’s first understand how cancer has traditionally been treated.

TRADITIONAL CHEMOTHERAPY

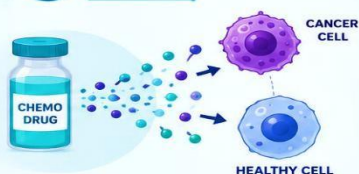
Chemotherapy is a cancer treatment, that uses powerful chemicals and drugs to kills or stop the growth of rapidly dividing cancer cells. It may be used alone or with other treatments such as surgery or radiation therapy.

Although this treatment has saved countless lives, it **has several significant Limitations:**

Common Side Effects of Traditional Chemotherapy

-  Hair loss
-  Nausea
-  Fatigue
-  Low immunity
-  Damage to healthy tissue

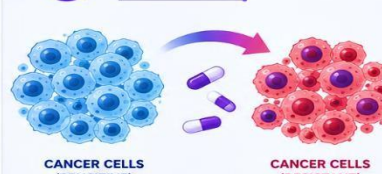
01 NON-SELECTIVE ACTION



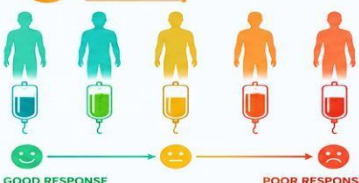
02 SEVERE SIDE EFFECTS



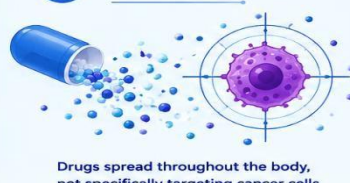
03 DRUG RESISTANCE



04 VARIABLE PATIENT RESPONSE



05 LIMITED PRECISION



06 RISK OF CANCER RECURRENCE



Those mentioned Limitations have driven Scientists to develop a more precise, personalized, smarter and targeted approach to the next generation of cancer treatment—**CHEMOTHERAPY 2.0**



DID YOU KNOW?

- A tumor can contain billions of cells, but not all are genetically identical.
- Nanoparticles used in cancer therapy can be thousands of times smaller than the width of a human hair.
- Some modern cancer drugs act like "guided missiles," targeting cancer cells while largely sparing healthy ones.



CHEMOTHERAPY 2.0

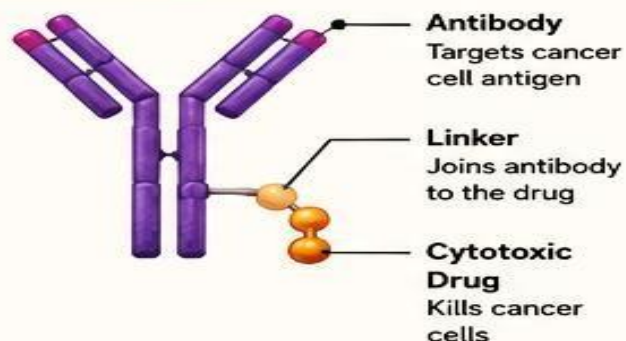
Chemotherapy 2.0 is the next generation of cancer treatment, that combines Precision medicinal chemistry, Nanotechnology, Genomics, and Artificial Intelligence (AI) to deliver chemotherapy with greater accuracy to cancer cells while sparing the healthy tissues.

THE SCIENCE BEHIND CHEMOTHERAPY 2.0

1 ANTIBODY-DRUG CONJUGATES (ADCs)

The Guided Missile Against Cancer

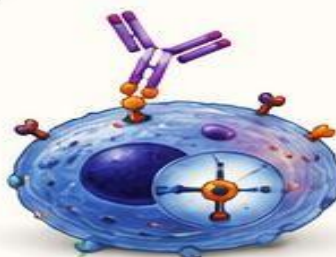
ADCs are at the heart of Chemotherapy 2.0. They combine the targeting ability of antibodies with the cell-killing power of chemotherapy drugs. The antibody recognizes a specific protein on cancer cells, binds to it, and delivers the potent drug directly inside. This precision attack maximizes cancer cell destruction while minimizing damage to healthy cells.



Cancer Cell



ADC binds to antigen



ADC is internalized into the cell

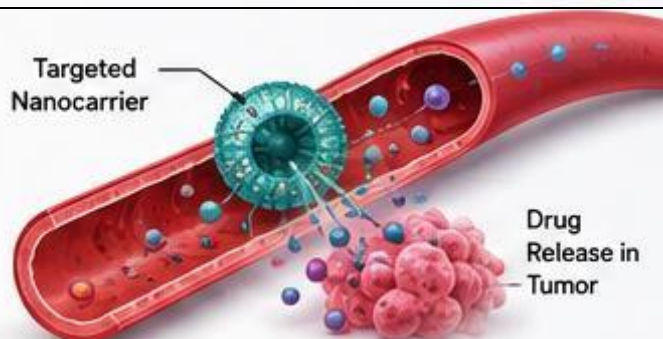


Drug is released and kills the cancer cell

2 TARGETED DRUG DELIVERY

Delivering Drugs with Precision

Targeted drug delivery systems transport chemotherapy drugs directly to the tumor site. This increases drug concentration in cancer cells while reducing exposure to healthy tissues, leading to fewer side effects and better treatment results.



3 PRECISION MEDICINE & GENOMICS

Treatment Tailored to the Individual

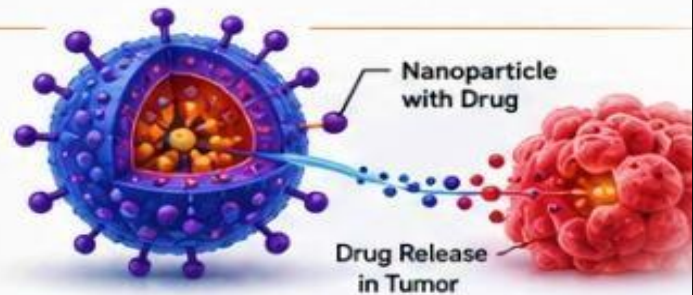
Genomic profiling identifies the unique mutations and biomarkers driving a patient's cancer. This enables doctors to choose the most effective drugs for that specific genetic profile, ensuring personalized and more effective therapy.



4 NANOTECHNOLOGY

Tiny Particles, Big Impact

Nanoparticles carry drugs safely through the bloodstream, protect them from degradation, and release them selectively in the tumor environment. This enhances drug stability, improves effectiveness, and minimizes harm to normal cells.



5 ARTIFICIAL INTELLIGENCE (AI)

Smarter Decisions in Cancer Care

AI analyzes vast amounts of clinical, imaging, and genomic data to predict treatment responses, identify the best drug combinations, accelerate drug discovery, and support doctors in making accurate, personalized treatment decisions.



HOW CHEMOTHERAPY 2.0 IS CHANGING CANCER CARE

❖ Better Treatment Outcomes

Chemotherapy 2.0 improves treatment accuracy by targeting cancer cells precisely, increasing effectiveness while reducing damage to healthy tissues.

❖ Fewer Side Effects

Technologies such as Antibody-Drug Conjugates (ADCs) and Targeted Drug Delivery minimize systemic toxicity, helping reduce common side effects like hair loss, nausea, and fatigue.

❖ Improved Quality of Life

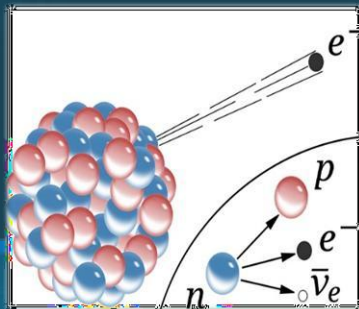
With safer and more personalized therapies, many patients experienced better treatment tolerance, faster recovery and an improved quality of life.

Quick Facts

- 1940s – Chemotherapy was first introduced for cancer treatment.
- More than 100+ chemotherapy medicines are used worldwide
- Precision Medicine – Uses a patient's genetic information to guide treatment decisions.
- Nanotechnology – Drug carriers are measured in nanometers (10^{-9} meters).

The future of cancer treatment is not about delivering more chemotherapy – it is about delivering the right therapy to the right patient at the right time. Chemotherapy 2.0 is transforming precision oncology from a vision into reality, offering new hope for safer, smarter, and more effective cancer treatment.

References: <https://pmc.ncbi.nlm.nih.gov/articles/PMC10446156/>



SAMRIDDHA ROY

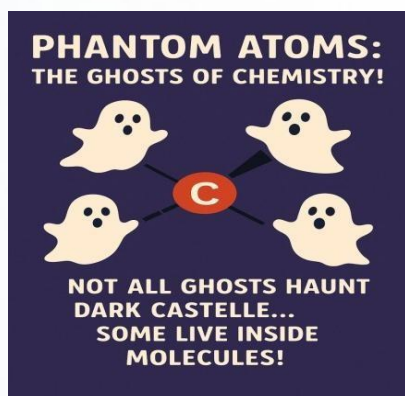
SEM-VII

The Phantoms of Quantum Chemistry:

Why Scientists Hunt for "Ghost Atoms"

Imagine an atom that has a soul, but no physical body. It occupies space. It has a shape. It can even interact with other elements. But if you look for its protons, neutrons, or electrons, you find absolutely nothing.

*This isn't a scene from a science fiction movie. In the world of quantum and computational chemistry, these entities are a daily reality. They are called **Ghost Atoms** (denoted as **Gh** in molecular modeling programs), and they are the invisible heroes keeping our digital chemical calculations from falling apart.*



What Exactly is a Ghost Atom?

In a traditional laboratory at Durgapur Government College, an atom is matter. It is a dense nucleus surrounded by a cloud of electrons.

But when we move chemistry onto a supercomputer, everything changes. Computers do not see physical matter; they see **mathematical equations called basis sets**. A basis set is a collection of wave functions that define the exact regions of space where an electron density is likely to float (atomic orbitals).

The Definition: A ghost atom is a coordinate point in a simulated molecular space that contains a full set of these mathematical atomic orbitals, but has **zero nuclear charge and zero electrons**. It is a disembodied mathematical phantom—all the "*spatial infrastructure*" of an atom, without any of the physical mass.

The Case of the Over-Friendly Molecules

Why do computational chemists intentionally program ghosts into their codes? To solve a notorious mathematical glitch called the **Basis Set Superposition Error (BSSE)**.

Imagine calculating the energy of **Molecule A** all by itself. The computer uses a specific amount of math equations assigned to it. But when Molecule A binds to **Molecule B**, they get very



close. Suddenly, Molecule A gets lazy and starts "borrowing" the empty mathematical equations belonging to Molecule B's space

Because more math equations naturally make a calculation look more stable, the computer generates an energy reading that is artificially low. It tells the scientist: *"Look! This bond is incredibly strong!"*

But it's a lie. The bond isn't strong; the computer just used extra math to make it look good.

Enter the Ghost: The Counterpoise Trick

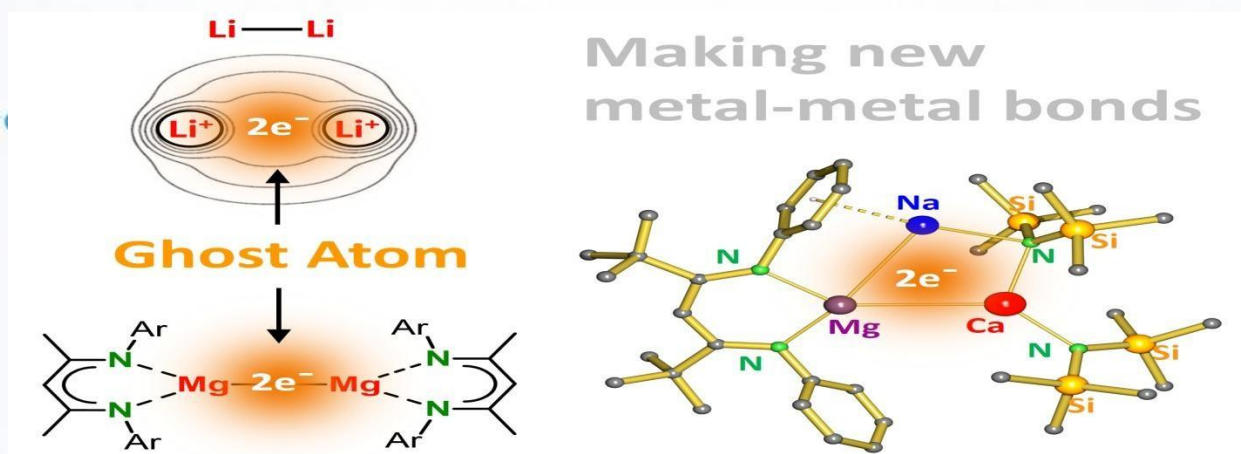
To stop this computational cheating, chemists use the famous **Boys-Bernardi Counterpoise Correction**.

To find the true, pure energy of Molecule A without any cheating, we must calculate it inside the exact same mathematical environment it had when Molecule B was next to it.

- **The Solution:** We calculate Molecule A next to a **Ghost Version** of Molecule B.
 - We completely delete Molecule B's nucleus and its electrons.
 - However, we leave its empty mathematical orbitals floating right where they were.
- By measuring Molecule, A inside this ghostly shadow, we isolate the math error perfectly. The result? Real, uninflated, pure chemical bond energy.

The Secret Lives of Chemical Ghosts

Fixing math errors isn't the only trick up their sleeves. Ghost atoms act as invisible multi-tools in modern research:



- **X-Raying Ring Currents (NICS):** How do we prove a ring like Benzene is truly aromatic? Scientists place a ghost atom right in the dead center of the ring. Because it has no electrons of its own to interfere, it acts as a clean, virtual probe to measure the hidden magnetic fields created by circulating (π)-electrons.

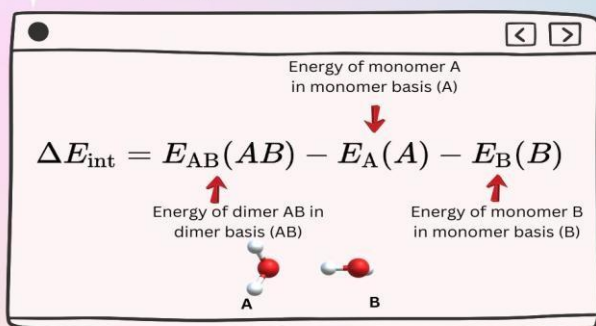
- **Symmetric Anchors:** They act as invisible "dummy points" to help modeling software define complex bond angles and molecular geometry centers when no real atom sits at that intersection.

G Real-World Showcase: The Vulnerable Water Dimer

Take the **Water Dimer (H₂O... H₂O)**, a system studied heavily in undergraduate physical chemistry. The true binding energy of a hydrogen bond between two water molecules is quite small (around 5 kcal/mol). Because this true interaction energy is so small, an uncorrected BSSE mathematical glitch can easily throw off the calculation by 10% to 20%, leading to completely incorrect predictions about macro-properties like boiling points or protein folding dynamics. By running the calculation with a ghost water molecule acting as a framework, we preserve the precision required for modern molecular design.

Basis set superposition error (BSSE)

When computing interaction energies of dimers as



one may observe artificial stabilization due to **BSSE** resulting in overbinding of the complex.

Quick Myth-Busting

Are they real? No. You cannot catch a ghost atom in a beaker. They only exist inside computer algorithms.

Are they the same as 'Ghost Particles'? Absolutely not! "Ghost Particles" is a nickname for Neutrinos in astrophysics. Ghost atoms are pure quantum chemistry mathematics.

🔗 Conclusion: The Matter of Math

The story of ghost atoms reminds us that at the quantum scale, chemistry transitions from tangible matter into pure mathematics. As we move deeper into the future of computer-driven drug discovery and materials science, these mathematical ghosts will remain vital sentinels, ensuring our calculations stay grounded in physical truth.

So, the next time you look at a complex chemical structure, remember: sometimes, the empty spaces are doing just as much work as the atoms themselves.

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https://www.bohrium.com/en/sciencepedia/feynman/keyword/ghost_atom



DEBAM GHOSH

7TH SEMESTER



The COLOURS of CHEMISTRY

Exploring the Spectrum of Science, Beauty & Life

INTRODUCTION

From the deep blue of the ocean to the green of leaves, from the red of sunsets to the bright hues of fireworks-colours surround us everywhere. But have you ever wondered what gives these colours their magic? Chemistry is the artist behind the palette. Of nature. In this edition, we take you on a colourful journey into the fascinating world where molecules absorb, reflect, and emit light to create the colours we see.

COLOURS IN CHEMISTRY

When electrons in atoms or molecules move between energy levels, they absorb or emit specific colours of light.

Colours in chemistry refer to the characteristic colours shown by different elements, compounds, or ions due to the way they absorb and reflect light. These colours help scientists identify substances and observe chemical reactions.

- KMnO_4 (Potassium permanganate) – Purple
- $\text{K}_2\text{Cr}_2\text{O}_7$ (Potassium dichromate) – Orange
- CuSO_4 (Copper sulfate) – Blue
- FeSO_4 (Iron (II) sulphate) – Pale Green
- AgCl (Silver chloride) – White
- AgBr (Silver bromide) – Cream
- AgI (Silver iodide) – Yellow
- $\text{CuO} / \text{MnO}_2$ – Black
- Fe_2O_3 (Iron (III) oxide) – Reddish Brown
- Sulfur – Yellow



Did you know? 💡

The purple colour of potassium permanganate solution is due to complex ions that absorb green light and reflect purple light.



TYPES OF COLOURS

Primary Colours:

Red, Blue, Yellow

Secondary Colours:

Green, Orange, Violet

Tertiary Colours:

Made by mixing primary and secondary colours.

COLOURS IN CHEMICAL REACTIONS

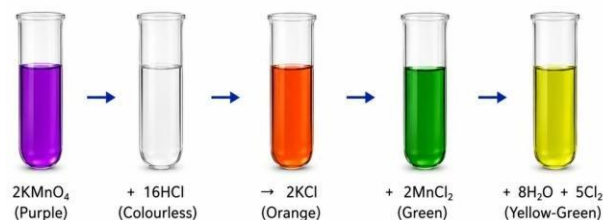
Many chemical reactions show beautiful colour changes, helping us understand and predict reactions.

pH INDICATORS: THE COLOR OF ACIDITY

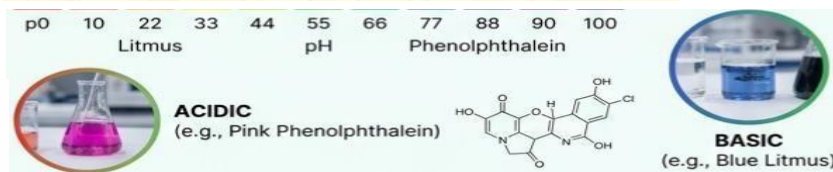
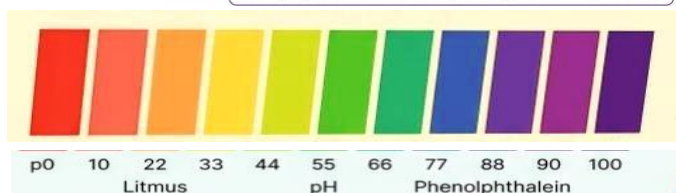
Commonly used compounds to procure the color indicators were spectranic (e.g., litmus, and litmus indicators reoulds, erspetriccv. Phenolphthalein, common examples are inotdable.

Copper(II) Sulfate ($\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$) Blue Used in fungicides and lab experiments	Potassium Dichromate ($\text{K}_2\text{Cr}_2\text{O}_7$) Orange Used in lab and as oxidizing agent	Potassium Permanganate (KMnO_4) Purple Used as disinfectant and in treatments	Nickel(II) Chloride (NiCl_2) Green Used in electroplating and ceramics	Mercury(II) Iodide (HgI_2) Red Used in lab (now restricted)	Sulfur (S_8) Yellow Used in medicines and matches
Cobalt(II) Chloride (CoCl_2) Pink (in solution) Used in humidity indicators	Iron(II) Sulfate (FeSO_4) Pale Green Used in iron supplements and water treatment	Iron(III) Oxide (Fe_2O_3) Reddish Brown Used in bricks, paints and rust prevention	Manganese Dioxide (MnO_2) Black Used in batteries and as catalyst	Zinc Oxide (ZnO) White Used in sunscreen, paints and ointments	Lead(II) Iodide (PbI_2) Bright Yellow Used in scientific research
Iodine (I_2) Violet-Black Used as antiseptic and in iodized salt	Chlorophyll (in plants) Green Gives green colour to plants	Carotenoids (in carrot) Orange Gives orange colour to carrots and fruits	Anthocyanins (in flowers) Red / Purple / Blue Gives red, purple and blue colours to flowers	Curcumin (in turmeric) Yellow Gives yellow colour to turmeric	Indigo (in blue jeans) Blue Gives blue colour to denim

COLOURS IN CHEMICAL REACTIONS



The purple solution of KMnO_4 turns green in acidic medium.



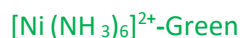
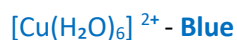
DID YOU KNOW?

There are more than 118 elements in the periodic table, and each has its own unique properties and uses!

METAL COMPLEXES & COLOUR

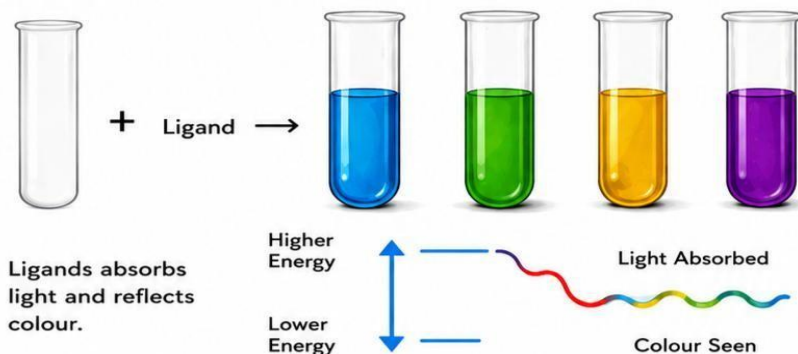
Many metal ions form complexes with ligands, and these complexes show stunning colours.

Examples: -



Why?

D-orbital splitting in metal ions absorbs specific wavelengths of light and reflects the rest as colour.



NANOCHEMISTRY & COLOURS

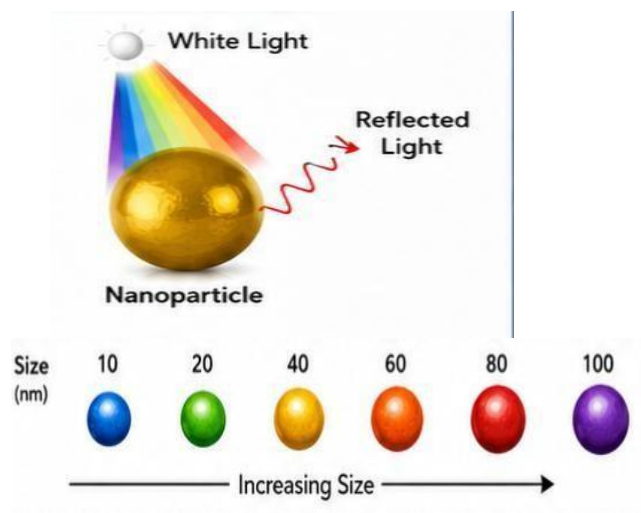
Nanochemistry studies materials at the nanoscale (1-100 nm).

At this scale, particles interact with light in unique ways, producing vivid and tunable colours.

HOW NANO SIZE CREATES COLOURS?

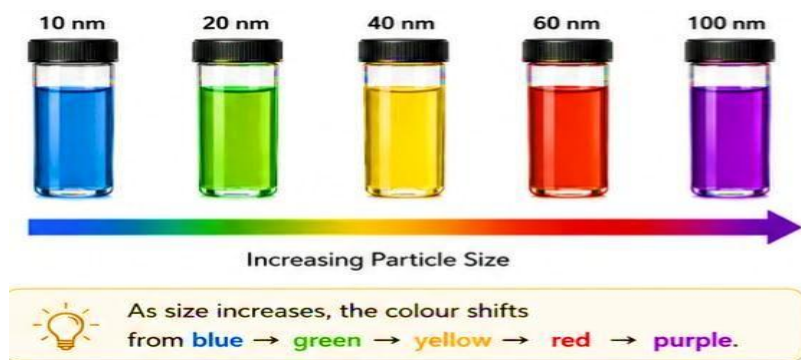
When light hits nanoparticles, the electrons on their surface vibrate together (surface plasmon resonance).

Different sizes absorb and reflect different wavelengths of light, so we see different colours.



COLOUR CHANGES WITH SIZE

Gold nanoparticles show different colours depending on their size.



Did you know?

Butterflies aren't just pigmented – their wings contain photonic structures that reflect certain wavelengths, creating brilliant colours without any dye!



TRY THIS SIMPLE COLOUR EXPERIMENT!

Rainbow Density Column

Materials: Honey, Dish soap, Water, oil, Alcohol, Food colouring, Glass or jar

How to do?

1. Pour each liquid slowly in order of density.
2. Add different food colours.
3. Watch the beautiful rainbow layers form!

Science behind it: Liquids have different densities and do not mix, creating distinct colourful layers



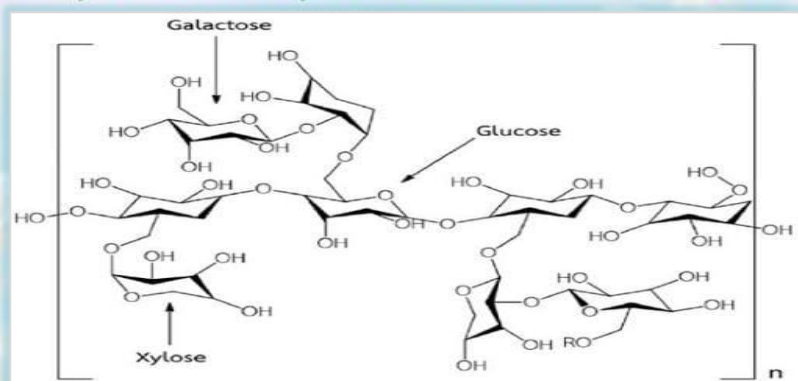
References: <https://www.ias.ac.in/article/fulltext/reso/006/03/0066-0075>



The Hidden Chemistry of Tamarind Seed

What if the biggest scientific breakthrough was hiding in the smallest kitchen waste?

- We eat tamarind.
- We enjoy its tangy flavour.
- Then we throw away the seeds.
- But hidden inside these tiny seeds is a remarkable natural polymer called **xyloglucan**—a material with unique binding and thickening properties.
- Today, scientists are exploring tamarind seeds for **clean water, green materials, medicine, and sustainable technology.**



A tiny seed. A world of possibilities.



SMALL SEED , BIG SCIENCE



The real magic of tamarind seeds lies in their chemistry.

- Scientists have found that their natural polymers can bind tiny particles together. In experimental studies, this property has been explored for removing microplastics from water by combining tamarind seed extracts with magnetic iron oxide particles. The resulting material helps gather plastic particles into clusters that can then be separated using a magnet.

Researchers are also studying tamarind seeds for:

- Eco-friendly water purification
- Biodegradable packaging materials
- Controlled drug delivery systems
- Natural food thickeners and stabilizers



Sometimes, the smallest discoveries create the biggest impact.

From Kitchen Waste to Global Innovation

The story of tamarind seeds reminds us that science often begins with curiosity. Instead of asking, "What is this?" researchers asked, "What can this become?"

This simple question has transformed an ordinary seed into a symbol of green chemistry—using nature-inspired solutions to solve environmental challenges.

Although many applications are still being researched, tamarind seeds have already shown enormous promise in building a more sustainable future.



Bishnupriya Pal
Sem - 07

Perhaps the next life-changing discovery won't come from a rare material or an expensive machine.

It may begin with something we once threw away.

Think Green. Think Chemistry. Think Beyond Waste.

References:

<https://eujournal.org/index.php/esj/article/view/6275/6047>

CHEMISRTY AND MYSTERY

Chemistry is often called the science of matter, but it could just as easily be called the **science of mysteries**. Behind every element on the periodic table, every chemical bond, and every reaction lies a question that scientists are still trying to answer. The more chemistry advances, the more it reveals how much remains unknown.

One of chemistry's greatest mysteries begins with the atom. Everything around us is made of atoms, yet no one has ever seen an atom in the way we see everyday objects. Instead, scientists have developed models to explain its behaviour. From Dalton's solid sphere to Thomson's plum pudding model, Rutherford's nuclear model, Bohr's planetary model, and today's quantum mechanical model, each has brought us closer to understanding atomic structure. Yet none is considered the final description of reality. The quantum mechanical model predicts where an electron is most likely to be found, but its exact nature remains one of the most fascinating questions in science.

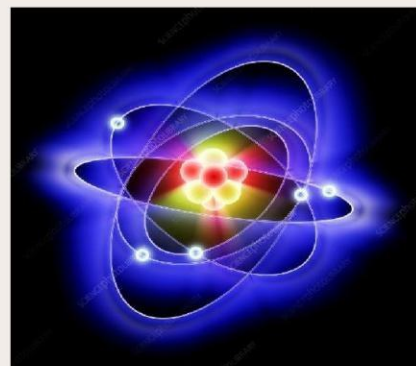
Another enduring mystery is the **chemical origin of life**. How did simple molecules on the early Earth assemble into the first self-replicating system? How did non-living matter give rise to living cells? Chemists, biologists, and geologists have proposed many ideas, but no single explanation has been universally accepted. Solving this puzzle would not only explain our own beginnings but also help us understand whether life could exist elsewhere in the universe.

Because chemistry is filled with such unanswered questions, it is sometimes viewed as a subject of mysteries. But that is not a weakness—it is the very reason chemistry continues to grow. Every mystery inspires a hypothesis. Every hypothesis leads to experiments. Every experiment brings us closer to the truth while revealing new questions waiting to be explored.

The history of chemistry is a history of curiosity. Every major breakthrough—from atomic theory to the periodic table and modern molecular science—began with someone asking a question that had no answer at the time. What was once considered a mystery became knowledge, and today's mysteries may become tomorrow's discoveries.

Perhaps, then, mystery should not be seen as something that makes chemistry difficult. It is what makes chemistry exciting. **Mystery is the fuel of chemistry.** It inspires curiosity, challenges imagination, and drives scientific discovery. As long as there are unanswered questions, chemistry will continue to evolve, revealing new secrets about matter, life, and the universe itself.

References: <https://www.gmwgroup.harvard.edu/chemical-origins-life>





I U P A C

KIRAN RAJBHAR

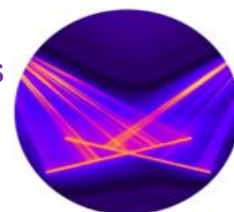
7TH SEMESTER



IUPAC'S TOP 10 EMERGING TECHNOLOGIES IN CHEMISTRY, 2025

This initiative showcases the strategic and innovative contribution of chemistry and chemists to the sustainable and the well-being of society serving as a platform to promote up-and-coming breakthrough to catalyze commercial uptake and technologies transfer.

XOLOGRAPHY It is a next generation 3D printing method that creates entire objects inside a transparent resin using intersecting light beams. Resin reaches its polymerization threshold only at the intersection of violet light (405nm) and red light (650-660nm) and together they activate the photo chemical system, producing enough radical to initiate polymerization only at desired location. It is much faster and more precise than conventional layer-by-layer printing without extra scaffolds.



Xolography

CARBON DOTS 2023 Noble prize winner colorful and ubiquitous carbon quantum dots are used widely from LEDs to the treatment of brain tumor. Carbon dots are zero-dimensional carbon nano materials value for their low toxicity, solubility, high stability and sustainability. Major advantage is possibilities in personalization, simple strategies to functionalize and decorate carbon structures to convey application in sensing, bio-imaging, drug delivery, solar cells and energy storage among others. Chiral carbon dots open new pathways for sensing complex bimolecular and driving reaction in photo catalyst, and site-selective CRISPR gene editing.



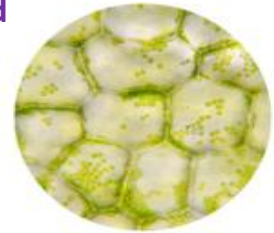
Carbon dots

NANO CHAIN BIOSENSOR It is the sensing element in the diagnostic device like COVID-19 testing nano chain biosensor binds with SARS-CoV-2 if it is present. Nano chains are chain like nanostructures used as highly sensitive biosensor. They are coated with antibodies, enzymes, or DNA probes to recognize specific targets. It can picomolar to femtomolar concentration, sometimes even single molecules. Its application includes COVID-19 detection, influenza diagnosis, cancer screening, drug delivery, lab-on-a-chip devices and personalized point-of-care testing.



Nanochain biosensors

SYNTHETIC CELLS We need to know the working of a normal engine understand the working of a Bugatti. Similarly minimal synthetic cell was created at J. Craig Venter institute by reducing genome to half of its usual length while still staying viable as an organism. This gives us the idea that how cell works such as gene expression, Metabolism and molecular communication in body. It provides pioneering application in biotechnologies and medicine for synthetic and selective release of drug. Overall, it could provide a better understanding of life and simultaneously solution to boost health.



Synthetic cells

SINGLE ATOM CATALYST The future of catalyst is not more metal; it's making every atom count. Single Atom Catalysis (SAC) uses isolated metal atoms attached to a solid support instead of metal nano particles. Since every atom acts as an active site, SAC achieves nearly 100% atom efficiency, improving catalytic activity, selectivity, and recyclability while reducing metal usages. It has promising applications in energy conversion, CO₂ reduction and green chemical synthesis. Copper based configuration (Cu-N₂) are especially used for converting CO₂



Single atom catalysis

THERMO-GELLING POLYMER A temperature-responsive polymer that remains liquid at one temperature but forms a gel at another temperature. Some examples are Poloxamers (Pluronic), Poly (N- isopropyl acryl amide). At low temperature it exists as free-flowing liquid with rise in temperature it forms micelles. Micelles 3D network which traps water producing a stable gel.

Their injectability and sustained drug release capability make them highly valuable in drug delivery, tissue engineering, medical imaging. And regenerative medicine, offering safer and more effective biomedical treatments.



Thermogelling polymers

ADDITIVE MANUFACTURING It is very commonly known as 3D printing, manufacturing process in which 3D object is created by adding material layer-by-layer based on a digital CAD (Computer Aided Design) model. It can produce complex geometries in much less time, reduces material waste, rapid prototyping. It can print metal object using metal fine powder this is a new advancement in it. Formed metal objects are lighter yet strong.

Using light weight 3D-printed components in aircraft an automobile reduces fuel consumption, lowering CO₂ emissions and combat global warming.



Additive manufacturing

MULTIMODAL MODELS FOR STRUCTURAL ELUCIDATION

Structure elucidation is the process of determining the exact molecular structure of an unknown molecule.

Multimodal foundation models use AI to combine information from multiple spectroscopic techniques (IR, NMR, UV-Vis, MS, etc.) to determine molecular structures faster, more accurately, and at lower cost than traditional single-technique methods, making advanced chemical analysis more accessible to laboratories worldwide. It has potential to speed up research, improve drug discovery new material and help chemist focus on research and innovation rather than repetitive works.



Multimodal models for structural elucidation

DIRECT AIR CAPTURE One of the main environmental problems we are facing today is Global Warming. To tackle with this problem, we have DAC (Direct Air Capture). DAC removes CO₂ directly from the atmosphere using chemical sorbents or advanced Metal-Organic Frameworks (MOF's). Amine functionalized MOF's enhance CO₂ capture and selectivity while enabling easier regeneration. Although costs have fallen below US \$100 per ton, challenges in scalability, energy demand and commercial viability still limit widespread deployment.



Direct air capture

ELECTROCHEMICAL CARBON CAPTURE AND CONVERSION

Electrochemical carbon capture and conversion uses electricity, preferably from renewable sources, to capture CO₂ and transform it into valuable chemicals and fuels such as Methanol, Ethylene, and Hydrocarbons. By combining capture with utilization, this emerging technology promotes sustainability, carbon circularity, and a cleaner chemical manufacturing future.



Electrochemical carbon conversion

DID YOU KNOW?

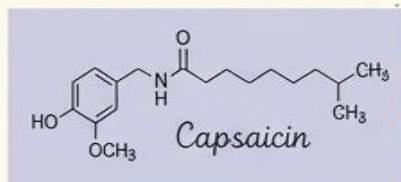
Microplastics are so widespread, from the deepest oceans to one of the most protected-purest places on earth – a Mother's Womb and we know, how they are harmful for the human health. Three 16-year-old Indian students (Vivaan Chhawchharia, Ariana Agarwal, and Avyana Mehta – turned discarded Tamarind Seeds into **Plas-Stick**, a biodegradable powder capable of binding to microplastics in water and allows them to be pulled out using a simple magnet. For their remarkable innovation, they won THE EARTH PRIZE 2026.

References: <https://iupac.org/what-we-do/top-ten/>



THE CHEMISTRY BEHIND CHILLI

- ❖ Chilli contains a natural chemical called **Capsaicin** (an alkaloid like compound).

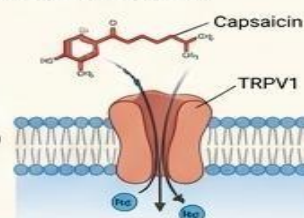


CHILLI AND ITS CAPSAICIN CONTENT



- Capsaicin doesn't increase the temperature of your mouth

Instead, Capsaicin binds to a specific binding site on TRPV1 (**TRANSIENT RECEPTOR POTENTIAL VANILLOID 1**) receptor found on pain-sensing nerve cells in the mouth and tongue.



- This binding changes the receptor's shape, opens its ion channel, and allows Na^+ and Ca^{2+} ions to enter the cell, sending a signal to the brain that is perceived as a burning sensation.

THE CHEMISTRY BEHIND IT (5-STEP PROCESS)

1. You Bite The Chilli

Capsaicin is released into the mouth.



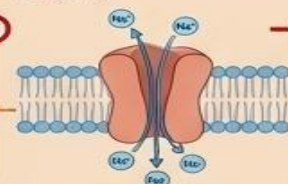
2. Capsaicin Binds

It attaches to the **TRPV1** heat receptors on the mouth.



3. The Receptors Activate

The receptors send "heat" signals to the Brain.



4. Brain Responds

Then feel a burning sensation, even through there is no real heat.



5. Body Reacts

You may sweat, Your eyes may water, as the body responds to the sensation.



DID YOU KNOW?

Drinking water usually doesn't stop the burning feelings because **Capsaicin is a non-polar (hydrophobic) molecule**, whereas water is a polar solvent. According to the principle "**like dissolves like**", non-polar substances do not dissolve well in polar solvents.

Milk contains fat and **Casein**, which can dissolve and bind to capsaicin. Hence, milk removes capsaicin more effectively than water, reducing the burning sensation.



FUN FACT

FUN FACT: Chili can make you sweat on a cold day. (Capsaicin activates TRPV1 heat receptors, making the brain perceive a sensation of heat. As a result, the body triggers sweating to cool itself, even though no actual increase in temperature has occurred.)

References:

<https://www.compoundchem.com/2014/01/15/why-chilli-peppers-are-spicy-the-chemistry-of-a-chilli/amp/>



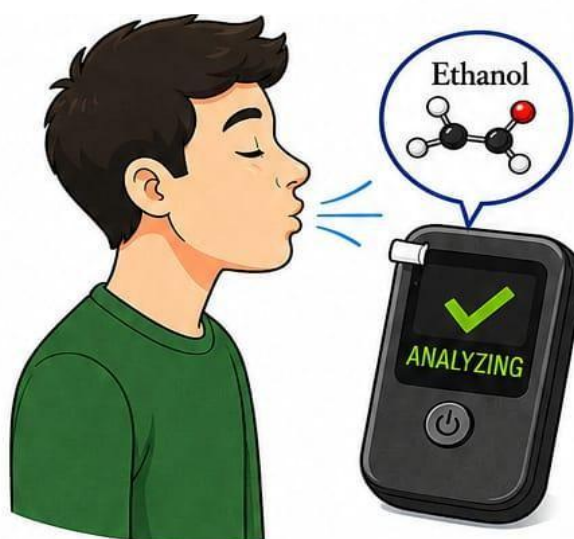
Blow, Breathe, Busted!! The Chemistry Behind Police Breathalyzers



Did you know?

Just one deep breathe can reveal whether you've been drinking or not. But how can a machine know what's inside your body? The answer is chemistry!

A police breathalyzer doesn't detect alcohol directly—it measures tiny amounts of ethanol in your breath using a chemical or electrochemical reaction. Because alcohol in your blood enters your lungs, one breath can reveal your blood alcohol level in just a few seconds!



Why does alcohol show up in your breath?

When someone drinks alcohol (ethanol), it is absorbed into the bloodstream through the stomach and intestines. As blood flows through the lungs, a small amount of alcohol evaporates into the air inside the lungs. Every time you exhale, this alcohol leaves your body with your breath.

This is why your breath acts like a “chemical fingerprint” of the alcohol in your blood.



1. You drink alcohol (ethanol)



2. Alcohol is absorbed into the bloodstream through the stomach and intestines



3. Blood carries alcohol to the lungs



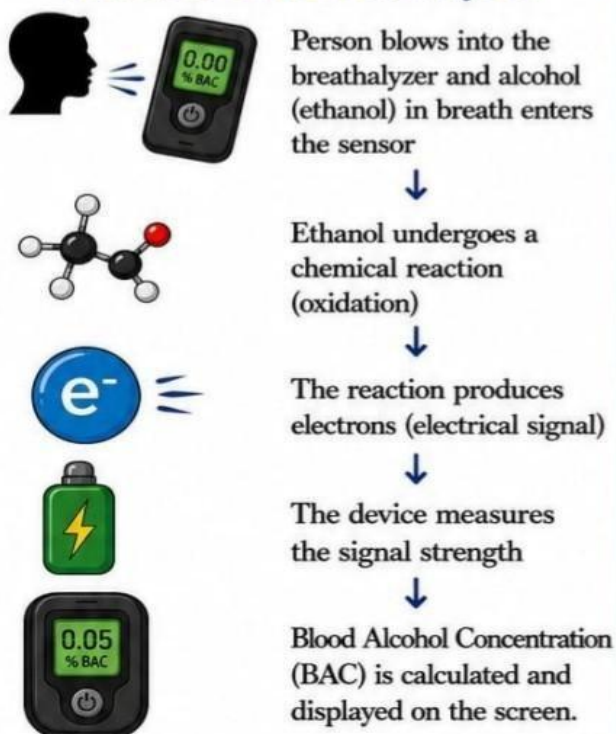
4. A small amount of alcohol evaporates into the air inside the lungs



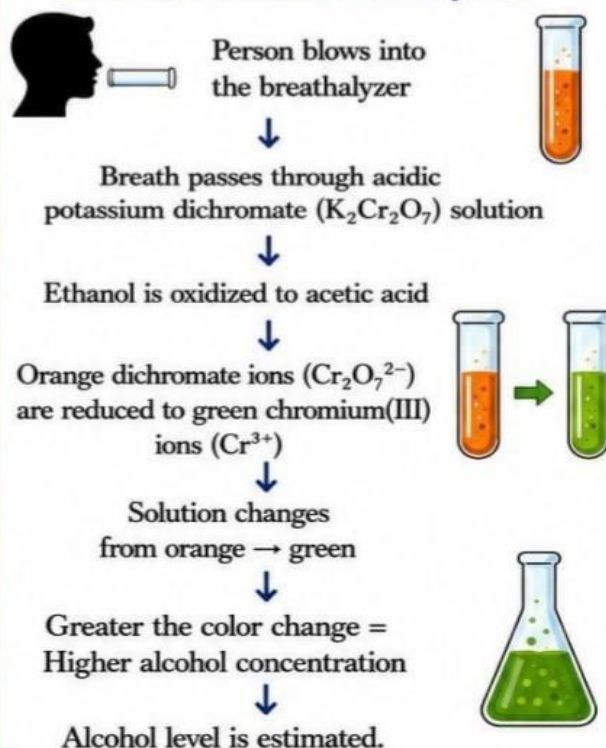
5. You exhale, and alcohol leaves your body in your breath

≡ The Chemistry Inside a Breathalyzer ≡

A. Fuel Cell Breathalyzer



B. Chemical Breathalyzer

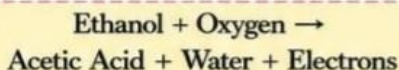


Fun Chemistry

Inside a breathalyzer, ethanol (alcohol) reacts with oxygen in a special reaction called oxidation.

This reaction produces acetic acid, water, and electrons.

In short:



More alcohol in your breath means more electrons are produced, which creates a stronger signal and shows a higher Blood Alcohol Concentration (BAC).

Fun Facts

- ◆ The first practical breathalyzer was invented in 1954 by American scientist Robert Borkenstein.
- ◆ Your breath contains hundreds of different chemicals, but breathalyzers are specially designed to detect ethanol.
- ◆ Modern fuel-cell breathalyzers are so sensitive that they can detect tiny traces of alcohol within seconds.

Takeaway



The next time you see someone blowing into a breathalyzer, remember: it's not the machine smelling alcohol—it's chemistry measuring it! Thanks to clever chemical reactions, a single breath can help prevent accidents and make our roads safer.



≡ One breath, one reaction, one result—chemistry has the power to save lives! ≡



References:

<https://sites.duke.edu/aep/module-4-alcohol-and-the-breathalyzer-test/science-content/redox-chemistry-inside-the-breathalyzer/>



RUDRA MAJI

5TH SEMESTER



THE CHEMISTRY BEHIND SUNSCREEN:

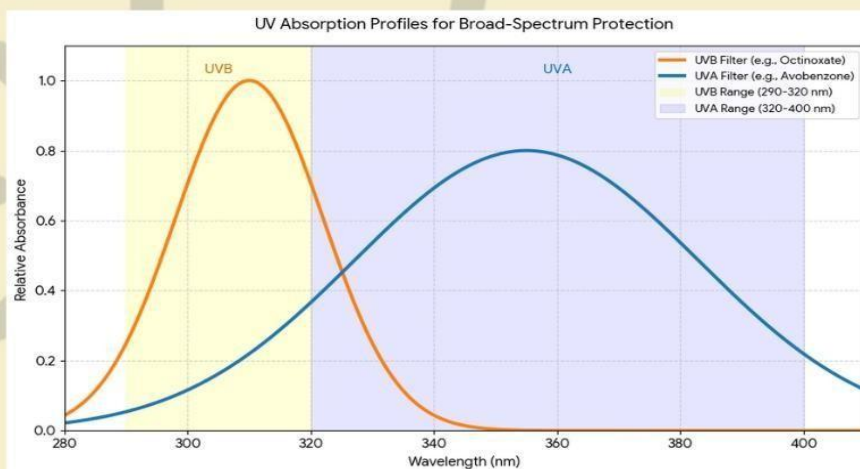
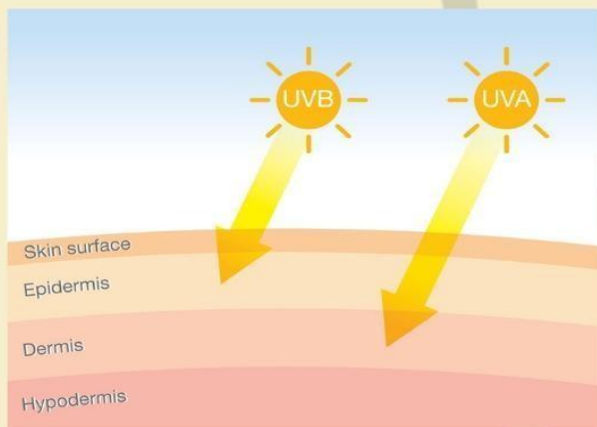
Every time you step out into the sun, your skin is exposed to ultraviolet (UV) radiation. While sunlight boosts Vitamin D, excess UV radiation causes premature aging, DNA damage, and skin cancer. Sunscreens act as a chemical shield

The Two Types of UV Rays

•UVA (315–400 nm): Penetrates deep into the dermis. Responsible for premature aging, wrinkles, and long-term cellular damage ("A" for Aging).

•UVB (280–315 nm): Affects the outer layer of skin. Causes sunburns and direct DNA mutation ("B" for Burning)

Sunscreen efficacy depends directly on a molecule's molar extinction coefficient (ϵ) across specific wavelengths. Broad-spectrum sunscreens achieve total coverage by combining distinct chemical entities: those that peak sharply in the UVB region (280–315 nm) and those engineered to absorb deeply into the UVA region (315–400 nm)



How Sunscreen Filters Work: Sunscreens rely on two main categories of active ingredients

A. Chemical (Organic) Filters

SUNSCREENS ORGANIC FILTERS RELY ON THE PRINCIPLES OF PHOTOCHEMISTRY AND EXCITED-STATE RELAXATION. THESE COMPOUNDS FEATURE CONJUGATED π -ELECTRON SYSTEMS (OFTEN AROMATIC RINGS COMBINED WITH CARBONYL GROUPS) THAT ABSORB SPECIFIC UV WAVELENGTHS.

Mechanism: The molecule absorbs a UV photon, promoting an electron from the Highest Occupied Molecular Orbital (HOMO) to the Lowest Unoccupied Molecular Orbital (LUMO).

Energy Dissipation: The excited state is highly unstable. The molecule rapidly returns to its ground state by releasing the absorbed energy harmlessly as heat (thermal dissipation) or, less commonly, as fluorescence. **Common Reagents:** Avobenzone (absorbs UVA), Oxybenzone, and Octinoxate (absorb UVB).

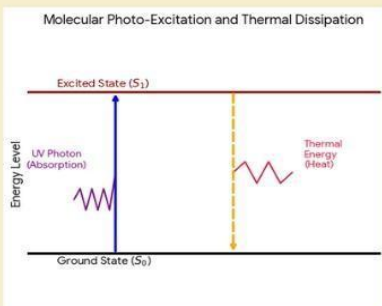
B. Physical/Mineral (Inorganic) Filters

MINERAL (INORGANIC) SUNSCREENS INORGANIC FILTERS USE PARTICULATE MATTER TO CREATE A PHYSICAL BARRIER ON THE STRATUM CORNEUM

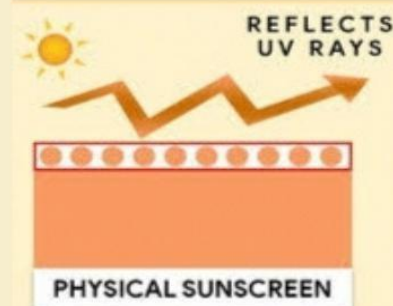
Mechanism: They primarily act by scattering and reflecting UV radiation away from the skin, though they also absorb a significant portion of UV light.

Chemistry: They rely on solid, water-insoluble metal oxides. Because they do not rely on a conjugated carbon skeleton absorbing photons, they are highly photostable. **Common Reagents:** Zinc Oxide (ZnO) and Titanium Dioxide (TiO₂)

A



B



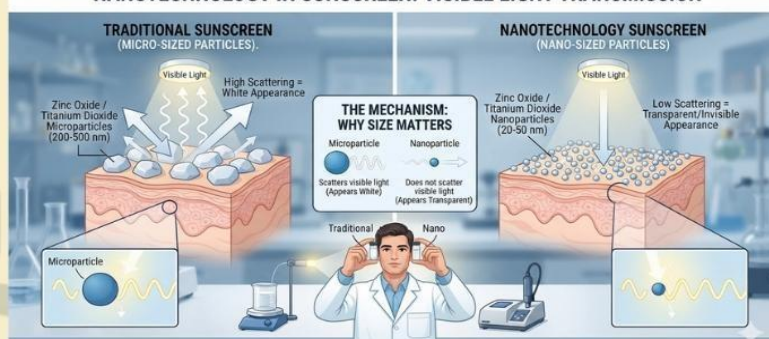
★problem of physical sunscreen-



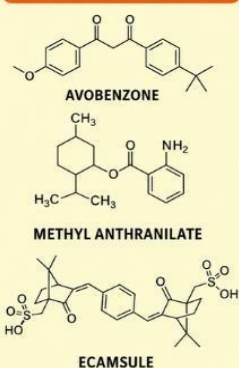
To solve

The Nanotechnology Advantage Formulators often use nanoparticles (sizes between 1-100 nm) of ZnO and TiO₂. Because the particle size is smaller than the wavelength of visible light (400-700 nm), visible light passes through uninterrupted. This solves the traditional "white cast" problem associated with physical sunscreens.

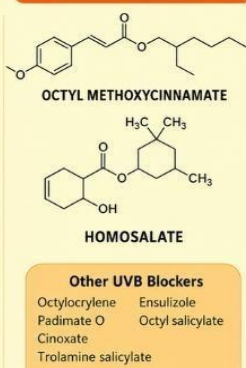
NANOTECHNOLOGY IN SUNSCREEN: VISIBLE LIGHT TRANSMISSION



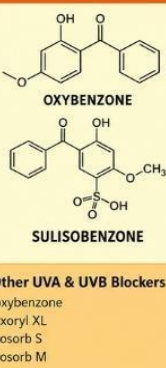
UVA Blockers



UVB Blockers



UVA & UVB Blockers

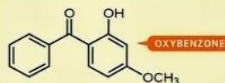


SUNSCREEN AND CORAL REEF DAMAGE

Sunscreen protects our skin from the sun, but there's also evidence that some of the lotion's ingredients may damage coral reefs. Here we look at the responsible compounds and efforts to combat the problem.

SUNSCREEN COMPOUNDS

Sunscreens use various compounds to protect our skin. These include inorganic pigments like titanium dioxide and organic compounds that absorb the ultraviolet radiation.



Oxybenzone and octinoxate are used in 70–80% of sunscreens. Sunscreen washes off when you swim or shower and can end up in the oceans.

14,000 METRIC TONS
The estimated mass of sunscreen released into the world's oceans every year

OXYBENZONE IN SEAWATER SAMPLES

US VIRGIN ISLANDS	HAWAII
OXYBENZONE CONCENTRATION 75–1,400 µg/L	OXYBENZONE CONCENTRATION 0.8–19.2 µg/L



EFFECTS ON CORAL

Coral gets stressed by pollution and changes in temperature, leading to coral bleaching. During bleaching, the algae that live on the coral and provide it with food leave or die.



Studies suggest that the organic compounds used in sunscreens, such as oxybenzone, can cause coral bleaching, making coral more susceptible to disease and death.

COMBATING THE PROBLEM



Hawaii will ban the sale of sunscreens containing oxybenzone and/or octinoxate in 2021. The Pacific nation of Palau will ban sunscreens containing these and eight other ingredients in 2020.



The evidence against these ingredients is largely limited to laboratory-based studies, which may not reflect conditions on reefs.

MINERAL SUNSCREEN ACTIVE INGREDIENTS

TITANIUM DIOXIDE, TiO₂
ZINC OXIDE, ZnO

Sunscreens based on solely inorganic minerals are considered to be safer for reefs. Chemists are also trying to develop naturally derived sunscreens.

The Role of SPF

SPF (Sun Protection Factor) indicates the ability of a sunscreen to protect against UVB radiation.

SPF 15 blocks about 93% of UVB rays.

SPF 30 blocks about 97% of UVB rays.

SPF 50 blocks about 98% of UVB rays.

Higher SPF values provide greater protection but no sunscreen can block 100% of UV radiation.

Conclusion: Sunscreens are a remarkable application of chemistry in daily life. By combining concepts from photochemistry, organic chemistry, and materials science, sunscreen formulations protect human health while continuing to evolve toward greater safety and environmental sustainability.

References:

<https://www.compoundchem.com/2014/06/05/sunscreenchemicals/>

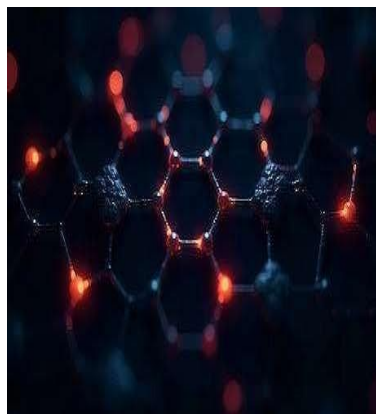


PRATYASHA DAS

5TH SEMESTER



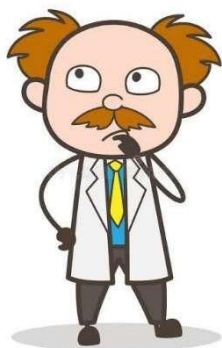
GRAPHENE: THE WONDER MATERIAL



INTRODUCTION

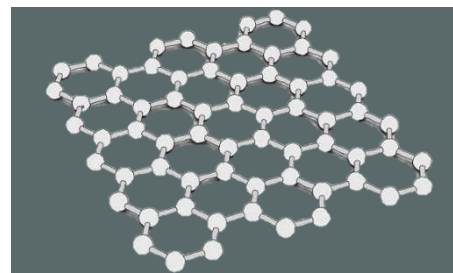


Imagine a material so thin that it's only one atom thick, yet so strong that it's about 200 times stronger than steel. That amazing material is graphene!



The story of graphene began with graphite, the same material found in ordinary pencil lead. For many years, scientists believed it was impossible to isolate a single layer of graphite because it would be too unstable.

*Everything changed in 2004, when two scientists, **Andre Geim** and **Konstantin Novoselov**, tried a surprisingly simple experiment. Using nothing more than **ordinary sticky tape**, they repeatedly peeled layers from a piece of graphite until they obtained a single layer of carbon atoms—graphene. This simple but brilliant experiment became famous as the "**Scotch tape method**."*



*Their discovery amazed the scientific world because graphene turned out to be incredibly strong, lightweight, flexible, and an excellent conductor of electricity and heat. Thanks to this groundbreaking work, **Geim and Novoselov** were awarded the **2010 Nobel Prize in Physics**.*





WHY IT IS CALLED WONDER MATERIAL?



Graphene is hailed as a "wonder material" because it is a single layer of carbon atoms arranged in a 2D honeycomb lattice. This unique structure makes it one of the thinnest, strongest, and most conductive materials on Earth. It possesses a record-breaking combination of physical and chemical properties:

- **Unmatched Strength:** Despite being only one atom thick, it is about 200 times stronger than steel but remarkably lightweight.
- **Superb Conductivity:** It conducts electricity better than copper and has superior thermal conductivity, efficiently dissipating heat.
- **Extreme Flexibility and Transparency:** It can stretch without breaking and is nearly 98% transparent, absorbing only about 2% of light.
- **Impermeability:** It is so dense that even the smallest gas molecules (like helium) cannot pass through it.

**DID YOU
KNOW?**

THE USES OF GRAPHENE.....LET ME TELL YOU....

Graphene is used in **electronics** for faster and smaller devices, **energy storage** in high-capacity batteries and supercapacitors, **solar cells** for better efficiency, **medical applications** such as drug delivery, biosensors, and tissue engineering, **water purification** through advanced filtration

membranes, **composite materials** to make aircraft, cars, and sports equipment stronger and lighter, **flexible displays** and wearable electronics, **sensors** for detecting gases, chemicals, and biomolecules, **thermal management** by improving heat dissipation in electronic devices, **protective coatings** to prevent corrosion, and **telecommunications** for highspeed signal transmission. Its exceptional strength, electrical conductivity, flexibility, and lightweight nature make it valuable across many industries.



References:

<https://ad-nanotech.com/why-is-graphene->



BABITA MURMU

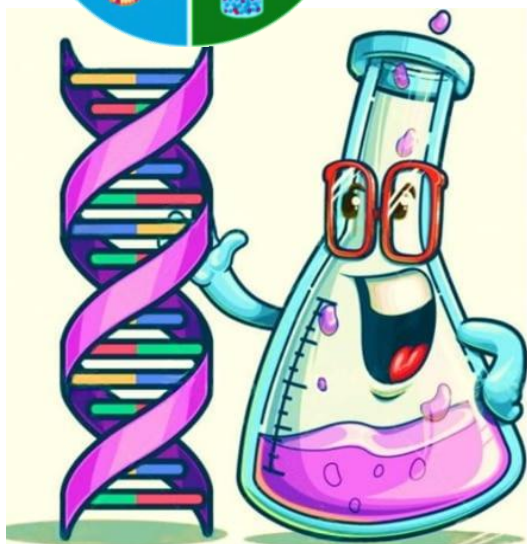
5TH SEMESTER



The Chemistry THAT KNOWS YOUR NAME

The future of Personalized Medicine

"Before the world knows your name, your molecules have already written your story."



📖 INTRODUCTION: ONE DISEASE, TWO DIFFERENT STORIES

Imagine two patients entering the same hospital on the same day. They are of similar age, suffering from the same disease, and are prescribed exactly the same medicine. A few weeks later, one patient recovers completely, while the other experiences severe side effects.

How can the same medicine produce such different outcomes?

The answer lies hidden within the microscopic world of molecules.

"Medicine treats diseases; personalized medicine treats the person behind the disease."

This simple question has led to one of the most exciting revolutions in modern science—**Personalized Medicine**, where chemistry, genetics, and medicine work together to provide treatment tailored to each individual.

THE SILENT LANGUAGE WITHIN

Within each heartbeat softly flows,
A hidden language no one knows.
No two souls are quite the same,
Each molecule remembers its name.

In every cell, in every vein,
Chemistry writes its sweet refrain.
Tomorrow's cure may finally see,
The perfect medicine begins with me.

EVERY HUMAN IS A DIFFERENT CHEMICAL UNIVERSE

Every person on Earth is unique. We differ not only in appearance and personality but also in our internal chemistry. Inside almost every cell lies DNA, the remarkable molecule that carries the instructions of life. Small variations in our genes influence how our bodies absorb medicines, break them down, and respond to them.

"Every cell is a library, every gene a sentence, and every molecule a word in the autobiography of life."

This explains why a medicine that works perfectly for one patient may be ineffective or even harmful to another. No two fingerprints are identical, and neither are the chemistries that define us.

WHAT IS PERSONALIZED MEDICINE?

Personalized medicine, also known as precision medicine, is an approach in which treatment is designed according to an individual's genetic makeup, biomarkers, and physiological characteristics.

Instead of asking,

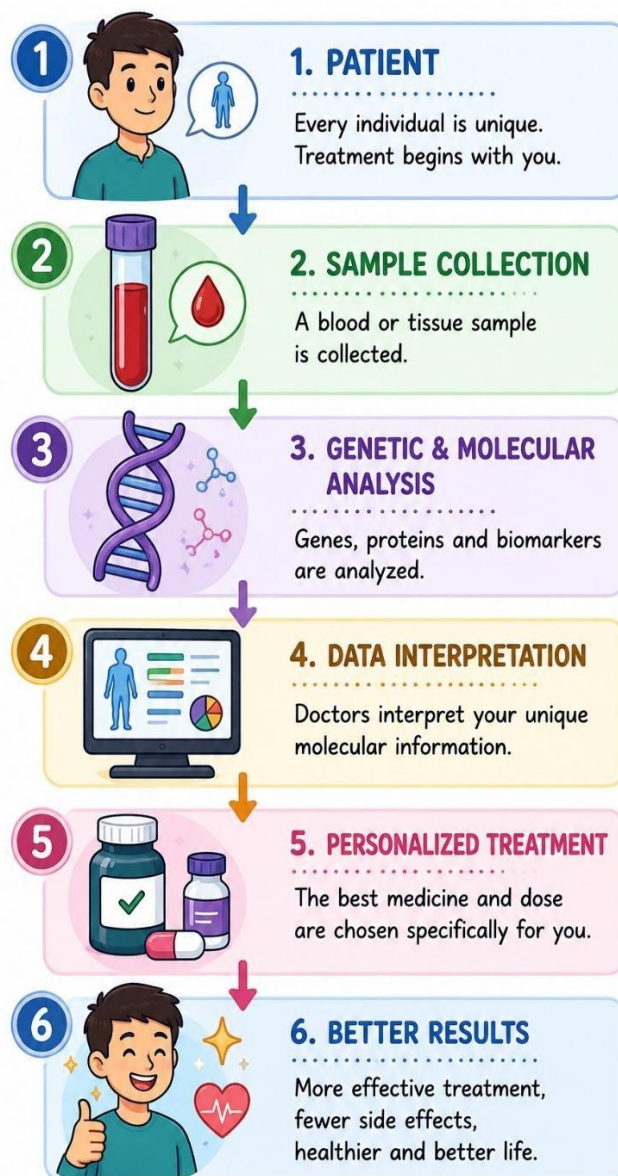
"Which medicine is best for this disease?"

modern science now asks,

"Which medicine is best for this particular person?"

By studying genes, proteins, enzymes, and molecular markers, doctors can predict how a patient may respond to a medicine and choose the safest and most effective treatment.

"Nature writes our genetic code; chemistry learns how to read it."



THE SILENT WORK OF CHEMISTRY

Whenever we swallow a tablet, an extraordinary journey begins. The medicine dissolves, enters the bloodstream, reaches different organs, and undergoes numerous chemical reactions. Tiny enzymes act like invisible chemists, transforming medicines inside our bodies. Some people break down medicines



rapidly, while others do so slowly. Some require higher doses, whereas others need lower ones.

The most extraordinary conversations in the human body happen without a single spoken word."

A tiny molecular difference may determine whether a medicine heals or harms.

💡 WHY IS THIS RESEARCH IMPORTANT?

Personalized medicine is not merely an interesting scientific idea; it has the potential to transform healthcare.

Firstly, it can reduce the trial-and-error approach often used in treatment by helping doctors choose the most suitable medicine from the beginning.

Secondly, it can significantly reduce adverse drug reactions. Every year, millions of people experience side effects because medicines do not affect everyone in the same way.

Furthermore, personalized medicine is becoming increasingly important in treating complex diseases such as cancer, diabetes, cardiovascular disorders, and rare genetic diseases. Certain cancer therapies are already being developed according to the genetic characteristics of individual patients.

This research may also reduce healthcare costs in the long term by preventing ineffective treatments and unnecessary hospitalizations.

"The future of medicine lies not in treating everyone the same way, but in understanding why everyone is different."

🚀 A GLIMPSE INTO THE FUTURE

Imagine visiting a hospital twenty years from now.

A doctor takes a single drop of your blood and analyses thousands of molecular signals within minutes.



The computer screen displays:

"This medicine is not suitable for your body."

Another message appears:

"A treatment has been designed specifically for you."

Not because it works for everyone. But because it works for you.

Scientists are already using genomics, biotechnology, nanomedicine, and artificial intelligence to make this future possible.

CONCLUSION

For centuries, medicine focused mainly on diseases. The medicine of tomorrow will focus on people.

Personalized medicine reminds us that every human being possesses a unique chemical identity deserving of equally unique care. Perhaps chemistry is not merely the science of atoms, molecules, and reactions. Perhaps it is also the science that quietly learns who we are—why our hearts beat, why medicines heal, and why every human body tells a different molecular story.

The future may not belong to medicines designed for millions. It may belong to medicines designed for one individual at a time.

"The greatest prescription of tomorrow may not be a new medicine, but a better understanding of the chemistry that makes you uniquely you."

Dedicated to the idea that every human being is unique—not only in thoughts and dreams, but also in chemistry

References:

<https://precision-medicine.magnusconferences.com/program/scientific-sessions/future-of-personalized-medicine>

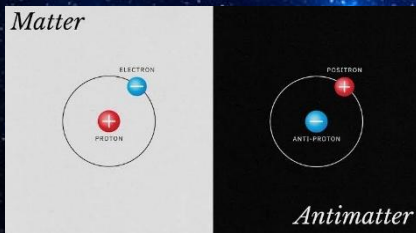
Dark Matter and Antimatter: The Mysterious Chemistry of Space

RIYA KAR
5TH SEMESTER



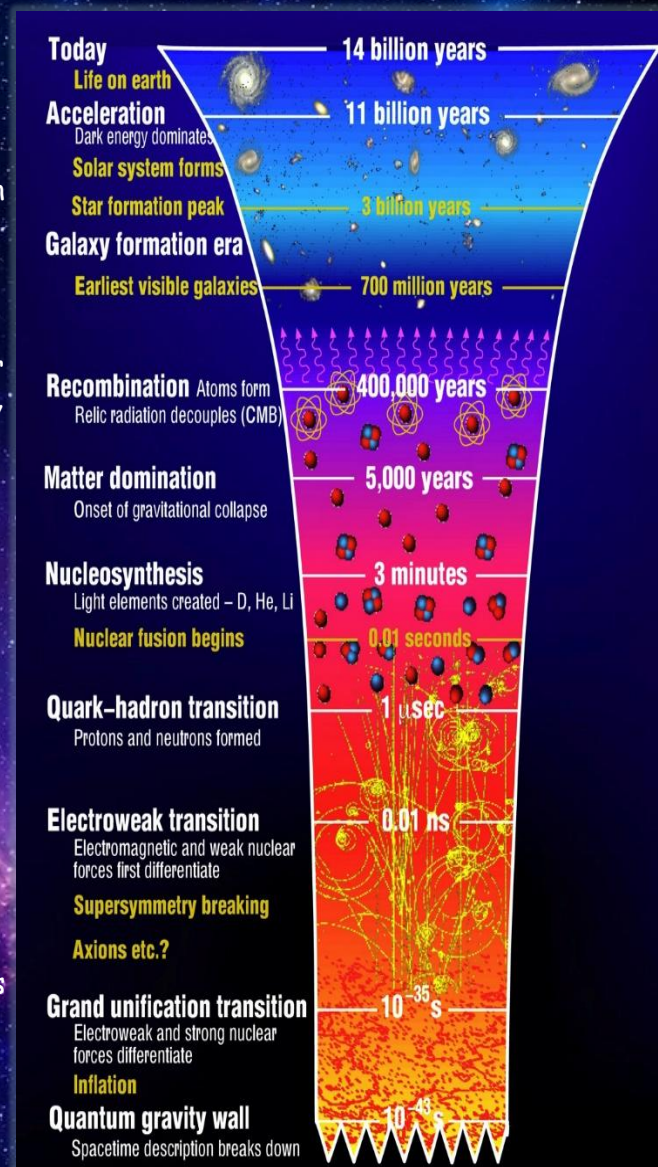
In the vast cosmic expanse, mysteries abound, and two enigmatic entities, dark matter and antimatter, stand as pillars of intrigue. Their existence, though elusive, shapes the very fabric of the universe. Let's delve into the realms of these cosmic enigmas, exploring their nature, significance, and the ongoing quest to understand them.

Dark Matter: The Invisible Matter



Dark matter constitutes approximately 27% of the universe, yet it remains unseen and undetectable through conventional means. It does not interact with light, making it essentially invisible. Its presence, however, is inferred through gravitational effects on visible matter. Galaxies rotate at speeds that defy predictions based on observable matter alone, hinting at the existence of a hidden mass—dark matter.

Scientists believe dark matter consists of exotic particles, distinct from the familiar atoms that make up ordinary matter. Here's a sobering fact: The matter we know and that makes up all stars and galaxies only accounts for 5% of the content of the universe! But what is dark matter? One idea is that it could contain "supersymmetric particles—hypothesized particles that are partners to those already known in the Standard Model. Experiments at the Large Hadron Collider (LHC) may provide more direct clues about dark matter. Many theories say the dark matter particles would be light enough to be produced at the LHC. If they were created at the LHC, they would escape through the detectors unnoticed. However, they would carry away energy and momentum, so physicists could infer their existence from the amount of energy and momentum "missing" after a collision. Dark matter candidates arise frequently in theories that suggest physics beyond the Standard Model, such as supersymmetry and extra dimensions. One theory suggests the existence of a "hidden valley," a parallel world made of dark matter with very little in common with the matter we know. If one of these theories proved to be true, it could help scientists gain a better understanding of the composition of our universe and, in particular, how galaxies hold together. Understanding dark matter is crucial for comprehending the large-scale structure of the universe. It serves as the gravitational scaffolding on which galaxies, galaxy clusters, and cosmic filaments are built. While its influence is undeniable, the precise identity of dark matter particles remains a puzzle, captivating the minds of physicists and astronomers alike.



Antimatter: The Most Expensive and Dangerous Version of the Particle Family

Antimatter is a mirror image of ordinary matter, composed of antiparticles with opposite charges. When matter and antimatter meet, they annihilate each other in a burst of energy, a process central to the early universe. Yet, in the cosmos we observe today, antimatter is conspicuously scarce. This asymmetry poses one of the greatest puzzles in modern physics: the matter-antimatter asymmetry.

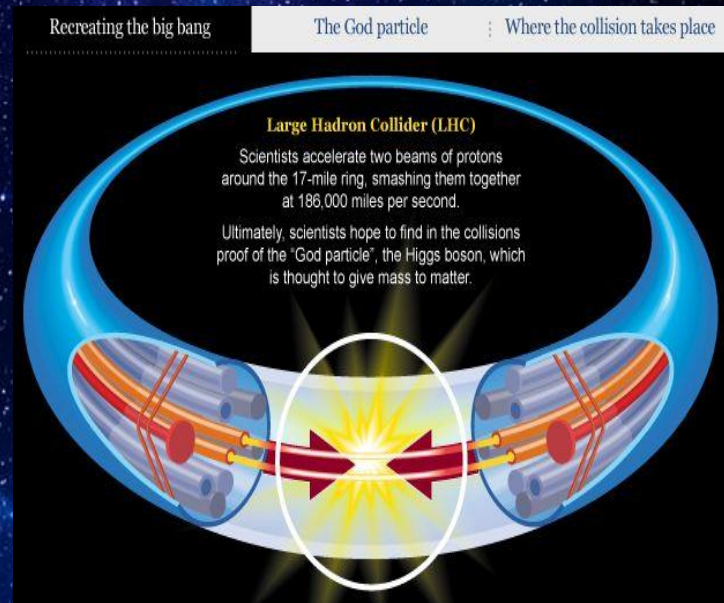
In 1928, British physicist Paul Dirac wrote down an equation that combined quantum theory and special relativity to describe the behavior of an electron moving at a relativistic speed. The equation, which won Dirac the Nobel Prize in 1933,

posed a problem: just as the equation $x^2 = 4$ can have two possible solutions ($x = 2$ or $x = -2$), Dirac's equation could have two solutions, one for an electron with positive energy and one for an electron with negative energy. But classical physics (and common sense) dictated that the energy of a particle must always be a positive number.

Dirac interpreted the equation to mean that for every particle, there exists a corresponding antiparticle, exactly matching the particle but with the opposite charge. For example, for the electron, there should be an "antielectron" or "positron," identical in every way but with a positive electric charge. The insight opened up the possibility of entire galaxies and universes made of antimatter. But when matter and antimatter come into contact, they annihilate, disappearing in a flash of energy.

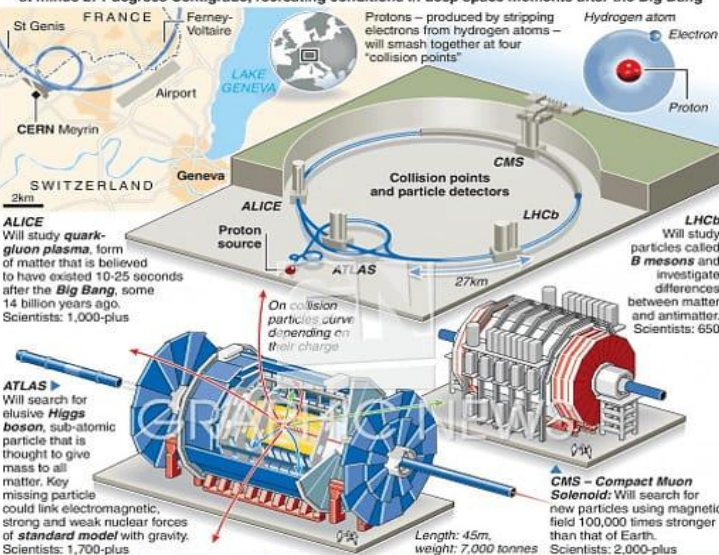
Cosmic Dance: Dark Matter and Antimatter Interplay

While dark matter and antimatter might seem unrelated, their coexistence hints at a deeper cosmic connection. The role of dark matter in the formation and structure of the universe could have influenced the distribution and evolution of matter, including the matter that makes up stars, planets, and life as we know it. Furthermore, the elusive nature of dark matter introduces a layer of complexity to our understanding of the universe's composition. As we probe deeper into the cosmos, the interplay between dark matter and other cosmic elements, including antimatter, promises to unveil additional layers of the cosmic tapestry.



Big Bang machine in search for smallest particle

The Large Hadron Collider (LHC) will accelerate two beams of protons around a 27km ring and smash them together at 99.99% the speed of light. Its 9,300 magnets will guide the particles through a vacuum at minus 271 degrees Centigrade, recreating conditions in deep space moments after the Big Bang



Unveiling the Cosmic Mysteries: Ongoing Research

Cutting-edge experiments and observations aim to pierce the veils surrounding dark matter and antimatter. Particle accelerators, like the Large Hadron Collider (LHC), seek to produce and study particles that might be related to dark matter and antimatter. Astrophysical observations, including those from space telescopes and detectors deep underground, provide crucial data for understanding their distribution and properties.

Reference:

<https://link.springer.com/article/10.1134/S1063779624701119>



The Breath Work of Atoms

The Chemistry of Human Machine

INTRODUCTION: BEYOND MECHANICAL BREATHING

When we think of breathing, we naturally imagine the mechanical pumping of the diaphragm and lungs. Yet, to the biological chemist, pulmonary ventilation is merely the macroscopic preamble to an exquisitely orchestrated quantum mechanical transaction. At the cellular level, respiration is a precise cascade of electron transfers, proton gradients, and metalloprotein interactions—a thermodynamic tightrope walk preventing living cells from collapsing into equilibrium.

1. Metalloprotein Dynamics: The Magnetism & Shape-Shifting of Hemoglobin

Oxygen (O_2) transport begins with hemoglobin, a tetrameric protein containing four heme groups. At the heart of each heme lies a divalent iron ion (Fe^{2+}) suspended within a porphyrin ring.

Spin-State Transition

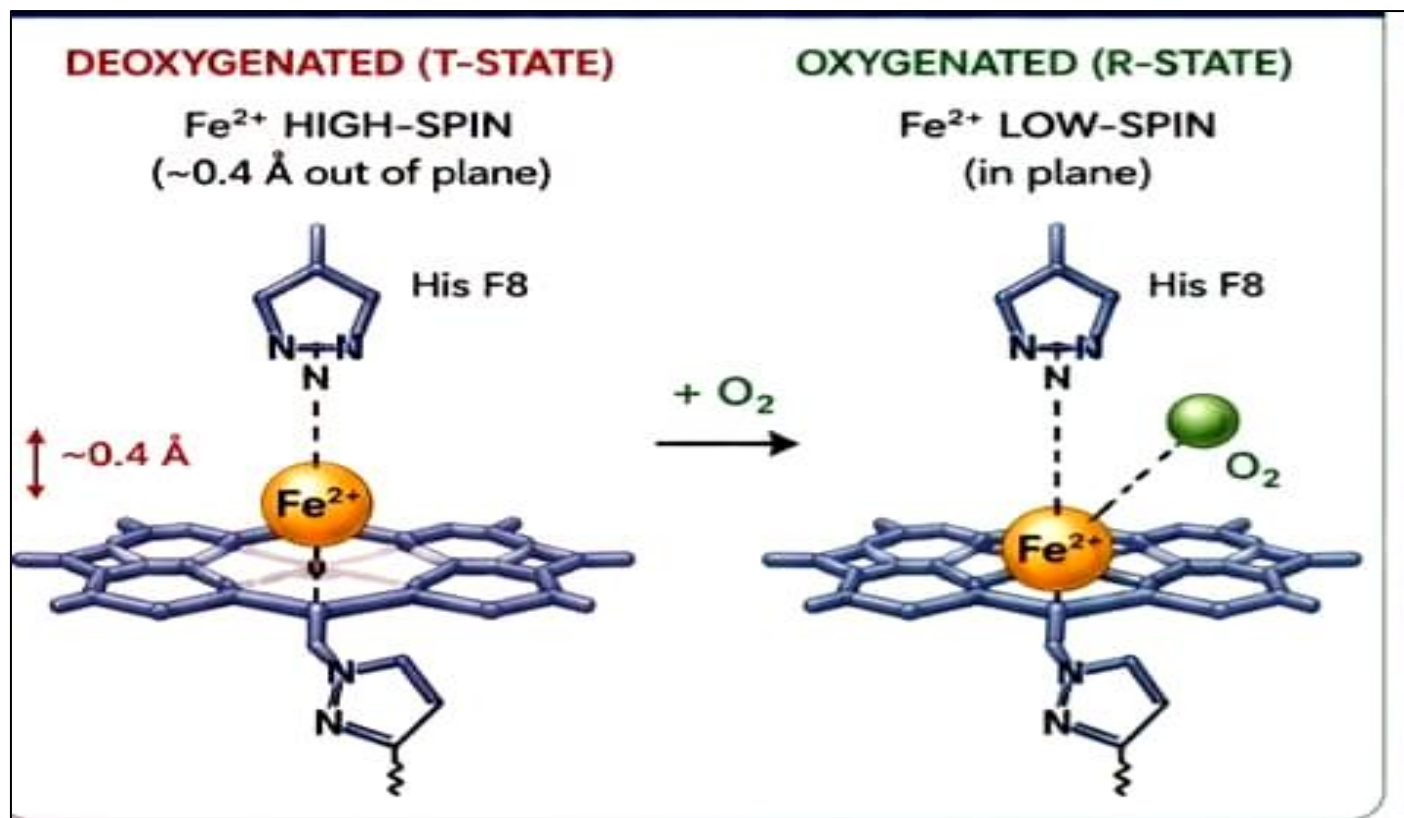
In deoxygenated T-state, Fe^{2+} is high-spin ($\sim 0.4 \text{ \AA}$ out of plane). Upon O_2 binding, it shifts to low-spin and snaps into plane.

Stereochemical Cascade

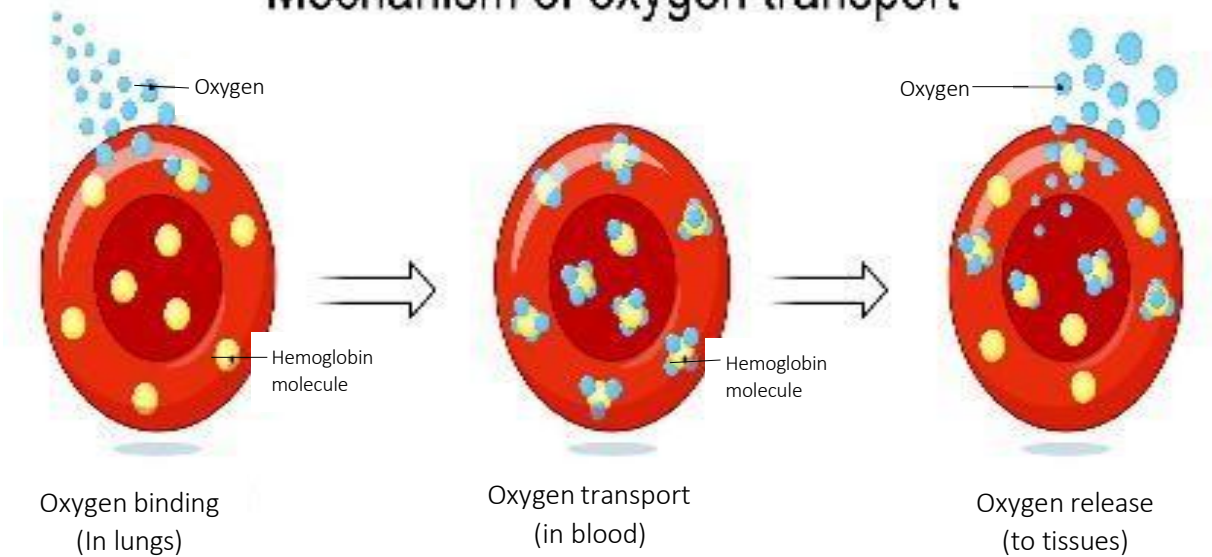
Pulls proximal histidine (His F8), breaking inter-subunit salt bridges and shifting quaternary structure to high-affinity R-state.

Allosteric Regulation

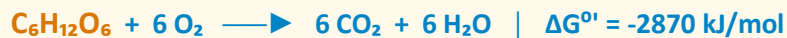
Elevated pCO_2 and lower pH protonate key residues (His146), stabilizing T-state to unload O_2 exactly where metabolically needed.



Mechanism of oxygen transport



Once inside the cell, oxygen acts as the ultimate terminal electron acceptor in oxidative phosphorylation. The overall stoichiometric equation of cellular respiration summarizes a complex series of coupled redox reactions:



The energy extracted from glucose breakdown is harnessed as electrons pass through transmembrane complexes within the inner mitochondrial membrane:

⚡ Complexes I & II (Entry Gates)

- Complex I: NADH: ubiquinone oxidoreductase (Transfers $2e^-$, pumps 4 H^+).
- Complex II: Succinate dehydrogenase (Transfers $2e^-$ from $FADH_2$, 0 H^+ pumped).

⚡ Complexes III & IV (Terminal Stages)

- Complex III: Coenzyme Q-cytochrome c reductase (Q-cycle, pumps 4 H^+).
- Complex IV: Cytochrome c oxidase (Reduces O_2 to $2H_2O$, pumps 2 H^+).

⚙️ 3. ATP Synthase: A Biological Nano-Turbine

Driven by the flow of protons rushing down an electrochemical gradient through its F_o domain, the enzyme's central shaft rotates at up to 18,000 RPM inside the catalytic F_1 head. This mechanical rotation physically deforms active sites through distinct conformational states (Open, Loose, Tight), compressing ADP and inorganic phosphate together to synthesize ATP continuously.

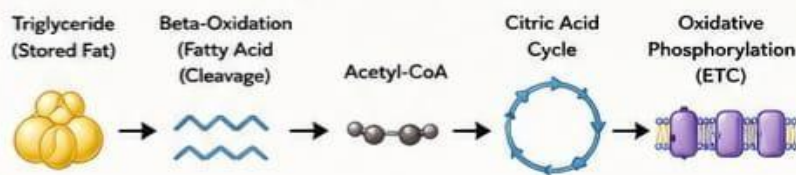
4. The Stoichiometric Fate of Biomass

When human tissue metabolizes stored lipids during aerobic exertion, hydrocarbon chains are systematically cleaved via beta-oxidation and the citric acid cycle.

4. THE STOICHIOMETRIC FATE OF BIOMASS

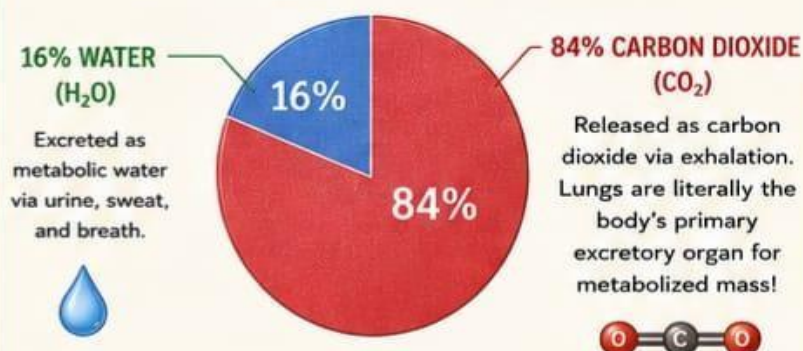
When human tissue metabolizes stored lipids during aerobic exertion, hydrocarbon chains are systematically cleaved via beta-oxidation and the citric acid cycle.

PROCESS OVERVIEW



QUANTITATIVE INSIGHT

Under complete aerobic oxidation of a typical triglyceride like tripalmitin ($C_{51}H_{98}O_6$):



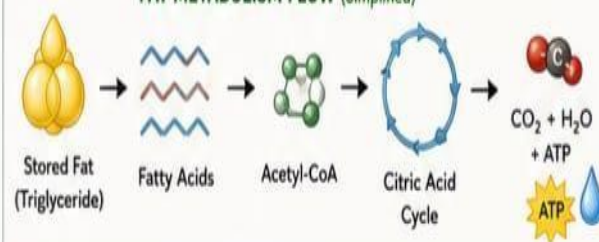
OVERALL STOICHIOMETRIC EQUATION (Example: Tripalmitin)



MASS FATE SUMMARY

Product	Chemical Formula	Mass Contribution (%)	How It Leaves the Body
Carbon Dioxide	CO_2	~84%	Exhaled via Lungs
Water	H_2O	~16%	Urine, Sweat, Breath

FAT METABOLISM FLOW (Simplified)



KEY POINTS

- ✓ Oxygen is the final electron acceptor.
- ✓ Electron flow pumps protons (H^+) across the membrane.
- ✓ Proton gradient powers ATP synthesis.

Respiration is far more than an involuntary reflex; it is a bio-quantum necessity. Every breath fuels a network of micro-motors, redox couples, and conformational switches operating at the nanometer scale. The next time we exhale, remember: we aren't just expelling air—we are discharging the spent carbon ashes of a microscopic engine keeping entropy at bay.

"In the end every breath is a chemical masterpiece, every heartbeat is a molecular rhythm, and every human being is living proof that the smallest atoms can create the greatest miracle—life itself."

References: <https://pmc.ncbi.nlm.nih.gov/articles/PMC8672270/>



SUCHANA DUTTA

5TH SEMESTER



Petrichor

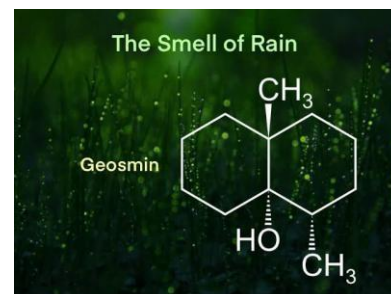
PETRICHOR: THE HIDDEN ORGANIC MOLECULES BEHIND THE EARTHY AROMA

- **Why does the Earth smell so beautiful after the first rain?"** Almost everyone has experienced this familiar fragrance, yet very few know that it is not the smell of rain itself. Instead, it is a fascinating story of chemistry, microbiology, and atmospheric science unfolding around us. Every raindrop carries with it an invisible chemical message, reminding us that nature is a laboratory where countless reactions occur every second.



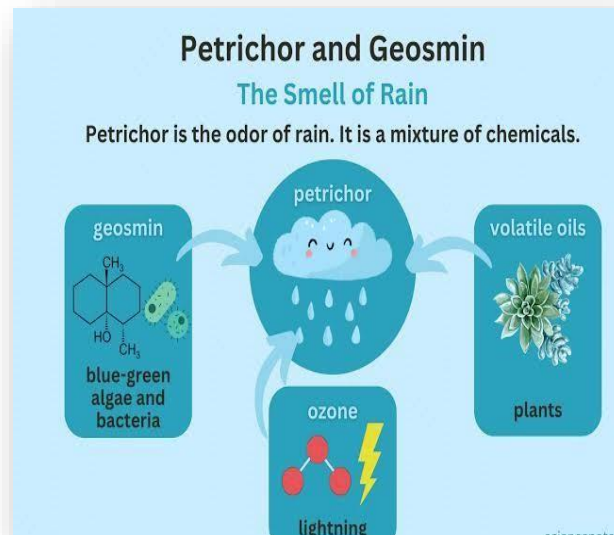
The pleasant earthy aroma that appears after rainfall has a scientific name **“PETRICHOR”**. The term was introduced in 1964 by Australian researchers **Isabel Joy Bear and Richard Thomas**. It is derived from the Greek words ‘**Petra**’ (stone) and **ichor** (the mythical fluid flowing through the veins of the gods), beautifully describing the unique scent released when rain falls on dry ground.

Contrary to popular belief, rainwater itself is almost odorless. The characteristic fragrance actually originates from the soil. During long dry periods, certain soil-dwelling bacteria, especially those belonging to the genus **Streptomyces**, produce an organic compound called **“Geosmin”**.



The word **Geosmin** literally means "earth smell." Humans are extraordinarily sensitive to this molecule and can detect it even at extremely low concentrations—far lower than many other naturally occurring compounds.

The chemistry becomes even more fascinating when the first raindrops hit the dry ground. As each drop strikes the soil, tiny air **bubbles become trapped beneath the surface. These bubbles quickly rise and burst**, releasing microscopic droplets known as "**aerosols**" into the atmosphere. **These aerosols carry Geosmin** and other volatile compounds into the air, where they are transported to our noses. What we perceive as the comforting smell of rain is actually the result of millions of invisible molecules traveling through the atmosphere.



- **Another contributor to the scent of rain is “ozone (O₃)”.** Before or during thunderstorms, lightning provides enough energy to split oxygen molecules (O₂). Some of the resulting oxygen atoms combine with other oxygen molecules to form ozone. This gas has a sharp, fresh smell that many people notice just before heavy rainfall. Thus, the fragrance associated with rain is often a combination of Geosmin, plant oils, and traces of ozone.



Plants also play an important role in creating petrichor.

During hot and dry weather, many plants release natural oils that accumulate on rocks, leaves, and soil surfaces. When rain arrives, these oils are washed into the air along with Geosmin, producing subtle differences in the smell of rain from one place to another. This explains why the scent after rain in a forest may differ from that in a grassy field or an urban park.

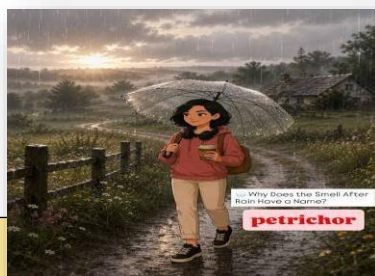


Interestingly, scientists believe that humans' appreciation of petrichor may have evolutionary roots. For our ancestors, rainfall often meant fresh water, fertile land, and better conditions for survival. Although this idea is still being studied, it suggests that our attraction to the smell of rain may be deeply connected to human evolution.

The chemistry of petrichor extends beyond curiosity. Geosmin is important in environmental monitoring, agriculture, water quality assessment, and even the food and beverage industry, where excessive amounts can affect the taste and aroma of drinking water and certain foods. Understanding these natural chemical processes helps scientists monitor ecosystems and improve environmental management.

The next time the first drops of rain fall and the air fills with that unforgettable earthy fragrance, remember that you are not simply smelling wet soil. You are experiencing an extraordinary interaction between microorganisms, atmospheric chemistry, plant compounds, and millions of microscopic molecules working together in perfect harmony.

Petrichor is a beautiful reminder that chemistry is not confined to laboratories—it surrounds us, enriches our everyday experiences, and reveals the hidden science behind the wonders of nature.



Did you know?

Humans can detect Geosmin at concentrations as low as 5 parts per trillion, making it one of the most easily detectable natural compounds by the human nose.

Imagine this.....

Close your eyes. The first raindrop touches the dry earth. Within milliseconds, millions of invisible molecules rise into the air, carrying a fragrance that has captivated humanity for thousands of years. That magical scent has a scientific name—**Petrichor.**



References:

<https://www.compoundchem.com/2014/05/14/thesmellofrain/>

Chernobyl: Echoes of an invisible disaster



Diya Chakraborty
5th Semester

“There are disasters that end in a day, and there are disasters whose consequences last for generations. Chernobyl belongs to the latter.”

There are moments in history that change the course of humanity forever. The Chernobyl nuclear disaster, which occurred on 26 April 1986, is one such event. What began as a routine safety test at the Chernobyl Nuclear Power Plant ended in the world’s worst nuclear accident exposing millions of people to radioactive contamination and leaving behind lessons that continue to shape the future of nuclear science.

The Chernobyl Nuclear Power Plant was located near the city of Pripyat in present-day Ukraine, then part of the Soviet Union. At the time, nuclear power was considered a symbol of technological progress and an important source of electricity. The plant used RBMK reactors, which were powerful but had design flaws that made them unstable under certain operating conditions.



Did you know?

Chernobyl is rated as the worst nuclear disaster in history till date at Level 7 on the International Nuclear Event Scale.

On the night of the accident, engineers were conducting a safety experiment on Reactor No. 4. The objective was to determine whether the reactor's turbines could continue generating electricity for a short period during a power outage until emergency generators became operational. However, a combination of human error, violations of safety procedures, and weaknesses in the reactor's design caused the reactor to become dangerously unstable. Within seconds, two powerful explosions destroyed the reactor building and ignited a graphite fire.



Did you know?

The explosion at Reactor no. 4 released around 4000 times more radioactive material than the Hiroshima atomic bomb.

Unlike ordinary fires, the burning graphite released massive amounts of radioactive material into the atmosphere. Winds carried radioactive particles across Ukraine, Belarus, Russia, and many parts of Europe. Initially, the authorities failed to recognize the true scale of the disaster, and many residents continued with their daily lives, unaware that they were being exposed to dangerous levels of radiation.

Among the first to respond were fire-fighters and plant workers, who displayed remarkable courage despite having little knowledge of the invisible danger surrounding them. They worked tirelessly to control the fire and prevent the disaster from becoming even more severe. Many suffered acute radiation sickness, and several lost their lives within weeks. Their bravery prevented further damage and remains one of the most inspiring aspects of the Chernobyl story.

Approximately 36 hours after the explosion, the nearly 50,000 residents of Pripyat were evacuated. They were instructed to carry only essential belongings because they were

Did you know?

More than 116,000 people were evacuated immediately, and another 220,000 were relocated in the following years.



expected to return within a few days. Sadly, they never returned. Homes, schools, hospitals, and public spaces were abandoned, leaving behind a city frozen in time. Today, Pripyat stands as a haunting reminder of the human cost of the disaster.

The effects of Chernobyl continued long after the explosions had ended. Large areas of land became contaminated, making farming and human settlement unsafe in many regions. Scientists observed an increase in thyroid cancer, particularly among children exposed to radioactive iodine shortly after the accident. Thousands of families lost their homes, while governments spent enormous resources on evacuation, healthcare, and long-term cleanup efforts. The Chernobyl disaster brought major changes to nuclear safety worldwide. Countries introduced stricter safety regulations, improved reactor designs, and enhanced emergency preparedness. In 2016, the New Safe Confinement was built over Reactor No. 4 to safely contain the remaining radioactive material.

Although the exclusion zone remains contaminated, wildlife has gradually returned, showing nature's ability to recover when human activity is absent. However, scientists continue to monitor the area because radiation still poses environmental risks. More than four decades later, Chernobyl stands as a lasting reminder that scientific progress must always be guided by responsibility, transparency, and strict safety measures. Its legacy continues to influence nuclear technology and serves as an important lesson for future generations.



Did you know?

The Chernobyl disaster changed nuclear safety regulations around the world. Many countries introduced stricter reactor designs, improved emergency procedures and stronger international cooperation to reduce the risk of similar accidents.

References:

<https://world-nuclear.org/information-library/safety-and-security/safety-of-plants/chernobyl-accident>



THE NUCLEAR FUEL CYCLE

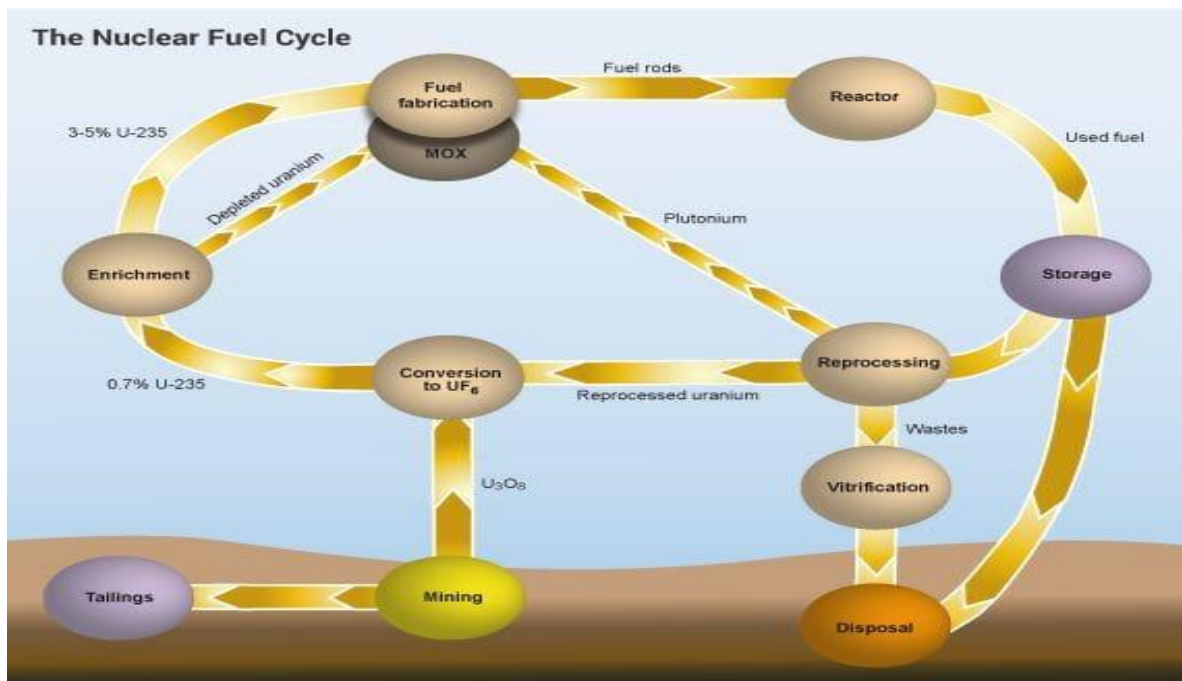
As the world faces the consequences of global warming caused by the use of fossil fuels, there has been a resurgence of interest in nuclear power. However, there is no “silver bullet”, and each energy-producing system produces waste. This issue of elements shows the importance of mineralogy in safe management by the nuclear fuel cycle.



- **NUCLEAR FUEL CYCLE PROCESS:** It splits into the following ways-
 - Front End of Cycle:** It consists of Mining and Milling, Conversion, Enrichment, Fuel fabrication, etc. It helps in preparing the fuel.
 - Reactor Operation:** Power Generation, irradiation, and nuclear reactor fall into this. It acts as a processor of the cycle.
 - Back End of Cycle:** It helps in managing waste or recycling from waste.

INTERESTING FACT

Nuclear fuel is so dense that all the used commercial nuclear fuel produced in the United States over the last 60 years would fit on a single football field stacked less than 10 yards deep.



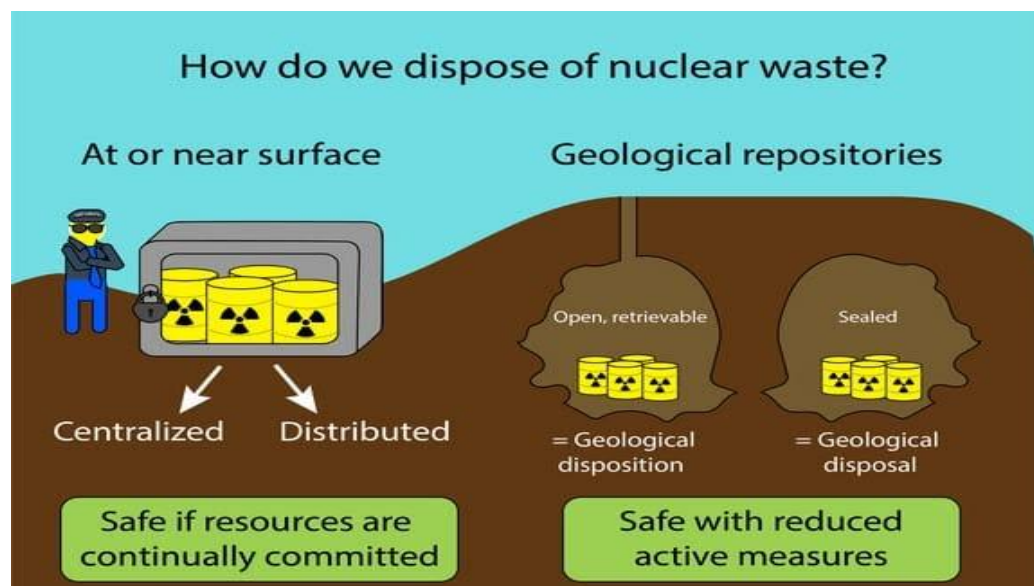
Its starting material is uranium, which is obtained from the ore available on the earth surface. These Earth Sciences explain how uranium behaves from natural rock formations to engineered repositories.

- **NUCLEAR WASTE DISPOSAL**

It isolates radioactive materials from humans and the environment. High-level spent fuel is cooled in water pools and permanently buried underground in stable rock formations called Deep Geological Repositories

- **CONCLUSION**

It concludes that, at its back end, where spent fuel is managed either through direct permanent disposal or via reprocessing and reinventing usable uranium and plutonium into a new fuel for the future use.



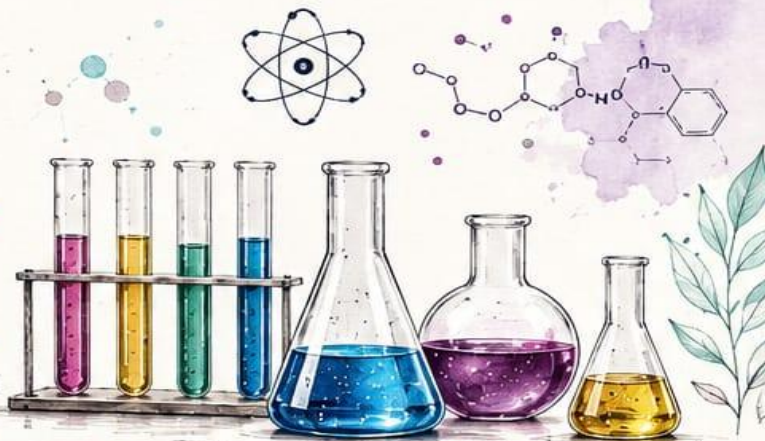
References <https://www.iaea.org/sites/default/files/18/10/nuclearfuelcycle.pdf>

FUN FACTS

from the fascinating world of

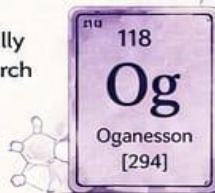
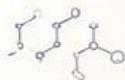
CHEMISTRY

BEYOND THE ORDINARY. DEEP INTO THE EXTRAORDINARY.



01 THE PERIODIC TABLE IS STILL GROWING

New elements are still being discovered! As of now, 118 elements are officially recognized, but the search continues for more.



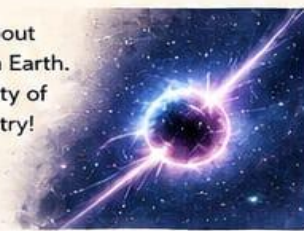
02 DIAMONDS ARE NOT JUST PRETTY!

Diamonds are made of carbon and are the strongest natural material known, with a hardness of 10 on the Mohs scale.



03 A SINGLE TEASPOON OF NEUTRON STAR MATERIAL

would weigh about 6 billion tons on Earth. That's the density of extreme chemistry!



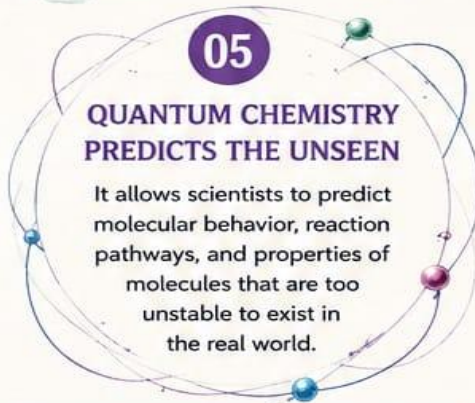
04 IRON IS ESSENTIAL, BUT TOO MUCH IS TOXIC

Iron is a key component of hemoglobin, the protein in our red blood cells that carries oxygen. But excess iron can cause oxidative stress and damage cells.



05 QUANTUM CHEMISTRY PREDICTS THE UNSEEN

It allows scientists to predict molecular behavior, reaction pathways, and properties of molecules that are too unstable to exist in the real world.



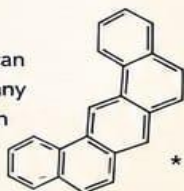
06 GOLD CAN BE BEATEN BY LIGHT!

In 2017, scientists showed that gold clusters can be ionized (lose electrons) using visible light — challenging the idea that gold is chemically inert.



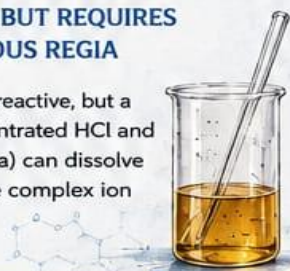
07 THERE ARE MOLECULES THAT ARE CHIRAL BUT HAVE NO CHIRAL CARBON!

Molecules like allenes, helicenes and biphenyls can be chiral without having any chiral (asymmetric) carbon atoms.



08 A DROP OF ACID CAN DISSOLVE GOLD, BUT REQUIRES AQUEOUS REGIA

Gold is highly unreactive, but a mixture of concentrated HCl and HNO₃ (aqua regia) can dissolve it by forming the complex ion [AuCl₄]⁻.



09 DNA IS A CHEMICAL MASTERPIECE

The human genome is made of just four nucleotides, yet it stores ~3 billion bits of information in a single cell nucleus!



10 SUPRAMOLECULAR CHEMISTRY CREATES MOLECULAR MACHINES

Scientists have built tiny machines at the molecular level like rotaxanes, catenanes and molecular motors that can move, rotate, and even perform work.



“ Chemistry is the poetry of matter. Everything you see, touch, feel, or think— is chemistry. ”



DID YOU KNOW?



The strongest covalent bond (known) is the triple bond in N₂.



Water can autoionize, producing H₃O⁺ and OH⁻.



Graphite and diamond are made of the same element — carbon.



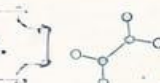
The pH scale was introduced by Søren Peder Lauritz in 1909.



Life on Earth is based on carbon chemistry.



CHEMISTRY: UNDERSTANDING NATURE, DESIGNING THE FUTURE.



Editorial NOTE & Acknowledgements

Dear Readers, Teachers, and Friends,

As editors, we take immense joy and pride in presenting this edition of our Chemistry Department Magazine. This magazine is not just a collection of pages, but a reflection of the scientific curiosity, creativity, and passion for chemistry shared by the students of Durgapur Government College.

Our Vision

Our main goal was to showcase that chemistry is not limited to complex equations and laboratory walls; it also has a beautiful, creative, and fascinating side. Through this magazine, we wanted to capture that spark of innovation within our student community.

Future Endeavours

This magazine is just the beginning of a long and inspiring journey. As we move forward, we hope this platform continues to evolve, sparking deeper scientific curiosity and encouraging even more students to share their innovative research and ideas. We envision future editions featuring interdepartmental collaborations, deeper alumni insights, and discussions of cutting-edge global discoveries. We look forward to seeing the next generation of students take this initiative to even greater heights.

Acknowledgements

We extend our heartfelt gratitude to everyone who made this journey possible:

- **Our Respected Professors:** For their invaluable guidance, constant encouragement, and insightful feedback.
- **Our Contributors & Peers:** For sharing their brilliant articles, creative writings, and scientific insights despite their busy schedules.
- **Technical Supporters:** For their dedication in designing and formatting this magazine to bring our vision to life.

Final Words

Since this is our first time stepping into the shoes of editors, please overlook any minor shortcomings. We would love to hear your thoughts, reviews, and constructive criticism. Your feedback will be our greatest motivation for the future.

Warm regards,
Editorial Board

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