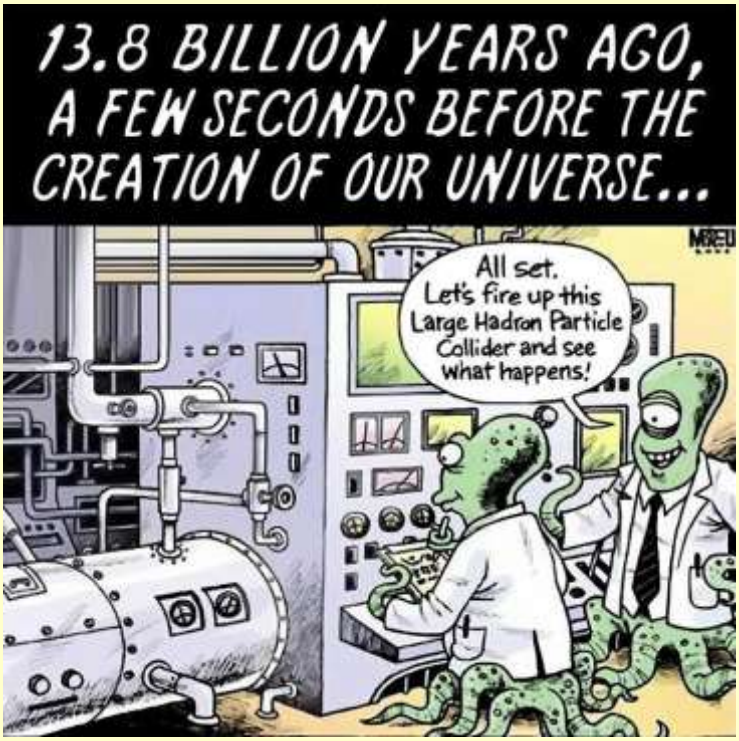
Navi Mumbai Science Foundation

EdUREKA

Education for Spirit of Science

Volume 5, Issue: No. 3 **July-September 2024**

LABORATORY OF CERN



Navi Mumbai Science Foundation

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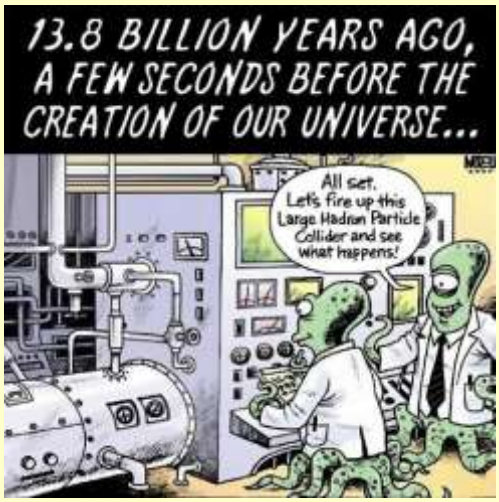
This is a quarterly e-magazine published by Navi Mumbai Science Foundation, a society engaged in spreading science education and scientific temperament among students of Navi Mumbai region for the last one decade. The magazine will mainly cover activities and articles on science education useful to students, teachers & society at large.

Contents .....



Views expressed in the magazine are from authors and editor may not agree with it.

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From Editor's Desk!!....

Editor's Corner

Dear Readers, students and teachers, we continue with our endeavor to bring articles to you which will give you a different perspective to things that you already know or introduce you to new concepts.

We bring you articles of interest in science, and interesting science/maths activities.

This issue also contains essays written by students, which won awards at Navi Mumbai Science Forum, essay competition. However, readers are urged to verify the content of the essays and the English language, independently. These essays are reproduced verbatim.

In case of essay competition, the overall prize went to Podar International school, Nerul.

Some activities are also included the solutions to those activities will be published in future articles.

Science at CERN

CERN (the European Organization for Nuclear Research) is one of the world's largest and most important centers for scientific research. Located in Geneva, Switzerland, CERN is best known for its groundbreaking work in particle physics, where it studies the fundamental particles that make up the universe.

For school students, CERN offers a lot of fascinating insights into how science works, especially in areas like physics, mathematics, engineering, and technology. Here are some key points about CERN that can be interesting and helpful for students:

Why we need CERN accelerator:

How do we see illumination of a candle? When the wax of candle, in the wick of the candle is heated, using a match stick, the wax evaporates and the molecules are excited by absorbing energy. They go up in air and at the same time they release the energy in such a way that we see the light, feel the heat and they heat up surrounding wax molecules. The process continues till all the wax is exhausted.

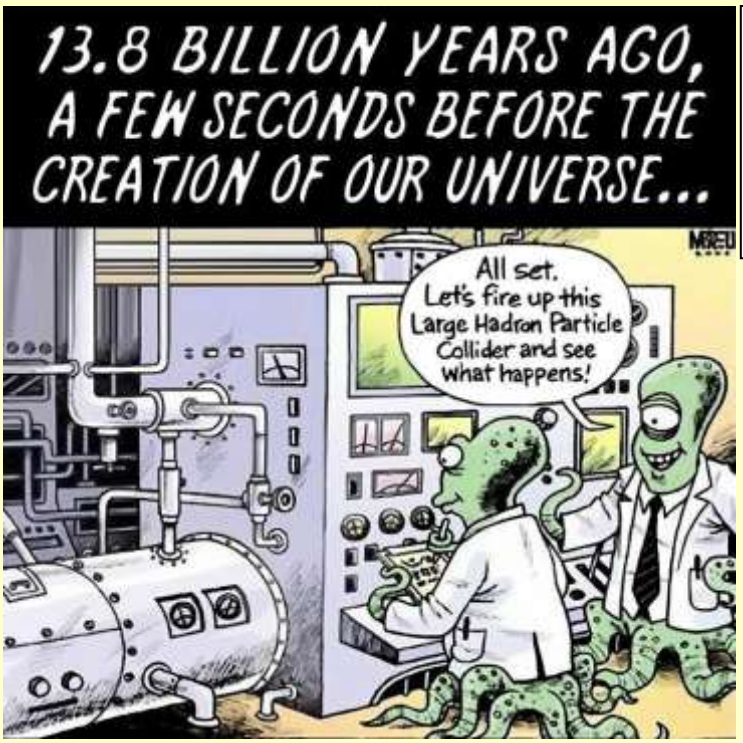
But the amount of energy that we deal with is hardly a fraction of eV and the temperature is few hundred degrees C or K. In order to achieve energy levels, required to "heat up" nuclei or sub-atomic particles we need energies of the order of several GeV (10^9). Thus we need different means to energies particles at such energies.

Hence we need accelerators which drive the nuclei (protons) at such high energies (velocities close to velocity of light). These particles when moving with such large amount of energies collide with each other they combined energies generate several new sub-atomic particles.

What Does CERN Do?

CERN operates a massive particle accelerator called the **Large Hadron Collider (LHC)**, the largest and most powerful particle accelerator in the world. It allows scientists to smash particles (hadrons) together at extremely high speeds, simulating the conditions of the universe just after the Big Bang. This helps them understand the fundamental forces and particles that make up everything around us.

What are hadrons: Imagine everything around you is made of tiny building blocks, like Lego pieces of tiny building blocks. These little building blocks are called particles. Some of these particles are really special and like to stick together to form bigger particles .one group of such particles that stick together are called hadrons and are made of tinier particles called **quarks.** Hadrons are very important because they make up the stuff around us. Protons and neutrons, which are hadrons, live in the nucleus (center) of atoms. The **LHC** is smashing the protons with protons (stripped from the Hydrogen atoms) with nearly speed of light. It is like smashing a toy car to see all its tiny parts inside which you can't see when its whole.



https://home.cern/science/accelerators/large-hadron-collider

https://www.youtube.com/watch?v=GOwfLBDMUHg

In the best case scenario, a proton (beam of protons) is accelerated from low energies to very high energies in stages using electromagnetic induction. It is not sufficient to just apply the force, it also has to be directed along a desired path. Hence the acceleration and the direction of the beam is done in small steps so that the protons do not deviate from their path and are lost. Another beam of anti-protons (same as proton but having negative charge) is similarly accelerated. These particles approach energies of the range of GeV which implies that velocity of these particles are around 99.999% of velocity of light.

The technology to direct the beams at 20% c is much easier than the technology required to direct and control particles moving at velocities of 99.999% c.

Hence, the idea of collisions of particles is very simple but the technology of the collision is extremely complicated and involves huge details.

In our next article we will discuss some technological challenges of an accelerator

Mandakini Patil

Tata Institute of Fundamental Research, Mumbai.

Biology first price

Svante Pääbo and his journey in Paleogenetics

Mukti Maisheri

Ramsheth Thakur Public School, Ulwe

There is a moment which defines success that “ah ha” moment, when the barrier of your expectations of what is possible to achieve is shattered. Imagine the world’s astonishment when Svante Pääbo’s persistence and ring work enabled the extraction and analysis of ancient DNA from long extinct hominins. Sharing light on their relationships with modern humans and rewriting narrative of our evolution. Pääbo’s journey is not just a scientific adventure. It is a story of human curiosity, pushing boundaries.

Svante Pääbo He is a distinguished and evolutionary biologist. He is affiliated with the Max Institute of evolutionary anthropology in life, Sikh Germany, and has received numerous awards for his pioneer contributions to the field of paleogenetics. Born in Sweden, he had interest in numerous subjects since young age. He was fascinated by Egyptology, which proved to be a formative step towards his career. Svante Pääbo’s work has been instrumental in the study of ancient DNA and its application to human evolution. Over the course of years with his everlasting curiosity and persistence. He has achieved remarkable accomplishments.

His journey was filled with daunting obstacles, severe DNA degradation in ancient specimens, the constant threat of contamination by modern DNA, and the low copy numbers of ancient DNA post significant challenges. To overcome these hurdles Svante Pääbo, had to be highly selective when choosing specimen for analysis, opting for those more likely to yield viable DNA. Understanding and distinguishing DNA in ancient samples was crucial. he emphasized replicability and independent verification to ensure the reliability of results. Access to well reserved. Specimen was Limited and interpreting genetic data from ancient DNA presented a complex task. Seeing these problems as a stepping stones, Pääbo, with his innovative methods, paved the way to specialize techniques for working with severely damaged, ancient DNA, including short DNA fragments, and optimized sequencing technologies. Rigorous contamination control was enforced, utilizing, dedicated classrooms and strict protocols. Pääbo devised ways to amplify low copy number, ancient DNA, enabling sufficient material for sequencing careful selection of well-preserved specimen in favourable conditions improved results. He also conducted extensive research to understand DNA damage and emphasize independent verification by other

laboratories, collaboration and global access expanded the scope of research, while his team developed methods for interpreting ancient DNA data.

In 1990, Svante Pääbo initiated a ground, breaking journey into the world of archaic DNA, his first major discovery in world extracting Neanderthal mitochondrial DNA (mtDNA) from a bone, which revealed that Neanderthals made no genetic contribution to modern humans. SMTDNA is maternally inherited it inside into our evolutionary history are limited, however, Pääbo's quest continued.

At the max plank Institute for evolutionary anthropology, life, see, he harnessed advanced sequencing technology from 454 life sciences to well into the Neanderthal genome. This high throughput method enabled the retrieval of. Neanderthal nuclear genome from select Boo samples, setting the stage for an ambitious project; sequencing the complete Neanderthal genome. Pääbo's research reshaped, our understanding of human evolution, he sequenced not only the Neanderthal genome, but also the Denisova genome. This revelation expressed the complexity of our past, with the Denisovans representing a distinct hominin group separate from Neanderthal and Denisovans. Adding layers to our understanding of population dynamics and legacy of archaic hominins.

These discoveries have triggered an explosion of genome sequences, from archaic, hominins and ancient Homo sapiens, shedding light on our complex evolutionary history. The genetic treasure trove offers valuable insights into the genetic diversity, isolation and unique evolutionary changes within Neanderthal population. Pääbo's work also Hinds at population, turnovers and highlights the significance of long-term occupation in places like the Denisova cave.

Discovery is regarding extinct hominins genomes, interbreeding with modern humans and Indian migrations have far reaching implications. They revealed the rich diversity of human genetics with. Neanderthal and Denisovan interbreeding contributing to modern traits. These findings challenge, linear human evolution, narratives, emphasising cultural, and genetic exchanges, the "out of Africa" theory is reinforced, shedding light on early humans, migration, and encounters with other hominins. Adaptive treats like immunity, hair, colour, skin, pigmentation, et cetera, acquired through interbreeding played, pivotal role in human evolution.

Culturally these discoveries promote as sense of shared human heritage, fostering inclusivity and discussions about our interconnectedness. Scientifically they advance paleo genomics, offering potential insights into other extinct species and ancient human populations.

These discoveries have opened doors to personalised medicine, anthropological insights, and a sense of shared cultural heritage advancements in paleogenomics may reveal more about extinct species and earth history. This is also prompt ethical

discussions on genetic engineering and privacy. Understanding fast climate adaptation can help address, current environmental changes, guiding future research, and application applications.

In the DNA of our ancient cousins, we have discovered not just the past but the blueprint for our future. The study of hominin genomes has shown that we are all connected by the thread of time, each generation building upon the legacy of those who came before. The story of our evolution is a narrative of resilience, adaptability, and our enduring quest for knowledge. It's a reminder that our history is far from starting and that the genomes of extinct hominins continue to shape our understanding of the ever evolving story of humanity. Or in Svante Pääbo's words, "With genetic data, we have more power than ever to trace our evolutionary history and discover the connections that wind all life on earth."

Keep evolving!

Chemistry, first prize

Noble prize winners, the torchbearers of science

Nayaab Nathani

St. Mary's ICSE School, Koparkhairne

"Chemistry is the poetry of matter, and the molecules are the words" - Jean Baptiste Perrin. Well, if chemistry is the poetry of matter, I believe that all the chemists are our poets, specialising in their respective feels, turning the mysteries of universe into solutions for the humankind. Chemistry, as a discipline, is not confined to laboratories and beaker alone. It permits every facet of our lives. From the medications that heal to the materials that build our world, from the food we consume to the energy that powers our homes, chemistry is the unseen force shaping our existence.

The noble prize in chemistry, established in 19 01 as one of the original noble prizes outlined in Alfred nobles, stands as a Testament to the enduring importance of the field. This recognition is not merely an acknowledgement of individual achievement, but collective who made to humanities journey into the micro-Cosmos of atoms and molecules. It is attribute, paid to the countless researchers and scientists who trial behind the scenes, driven by their passion for understanding the world on an atomic level. This honour reminds us that while a single name maybe hatched on the medal, it symbolizes the collective efforts of countless unsung heroes.

In the year 2022, Carolin Bertozzi, Barry Sharpless and Martin medal, where honoured with the noble prize, and where recognized as the torchbearers of innovation, illuminating the pathway for future generations of scientist, scientist, Barry Sharpless and Morten Medal, presented a ground, breaking research on click chemistry which is now widely used in various chemical aspects, Carolyn Bertozzi further and introduce this concept into the biological field and hence coined the term bio orthogonal reactions.

Barry Sharpless is a towering figure in the world of chemistry well-known for his profound impact in the field of chemistry and for his ground, breaking contributions to asymmetric synthesis. Born in 1941, Barry completed his bachelors and PhD, both from prestigious Stanford University beyond his Pioneer research, Sharpless has been a dedicated educator, inspiring and be numerous students and researchers. He has helped positions at several esteemed institutions, including the Scripps research Institute, where his expertise and passion have left an indelible mark on the next generation of scientists. In recognition of his outstanding contribution, he was awarded with the noble prize in chemistry in 2001, an honour that underscored the significance of his work and it's for reaching implications in summary, Barry

Sharpless luminary in the field of chemistry, celebrated for his transformative contributions to asymmetric synthesis and the creation of click chemistry.

Morgen Medal what is the Danish chemist whose enduring dedication to scientific exploration has significantly advanced boundaries of chemical research and has marked his career with multitude of accolades, including the noble prize in chemistry. He completed his bachelors and PhD from the technical University of Denmark from 1983 to 1988, he was a postop fellow in organic chemistry, first at DTU and then at MRC Lab of molecular biology at Cambridge and lastly, at University of Copenhagen, he has developed multiple techniques and instruments for peptide synthesis and for multiple column synthesis which is used in organic chemistry and in assembling large split mix libraries. He presented the cycloaddition of acetylenes and azides used in peptide and protein conjugation polymers, which was later on proved to be orthogonal for various other functional group chemistries.

Carolyn Bertozzi's journey in academia and research began with her education at Harvard University, where she earned her bachelor's degree in chemistry. She further honoured her expertise by obtaining a PhD from the University of California, Berkeley, her dedication to advancing the frontier of science and her intellectual prowess became evident early in her career. Beyond her pioneering research, she has been a dedicated educator and inspiring countless students to explore the dynamic realm of chemical biology. Her positions at various assisted institutions, including Stanford University, have allowed her to pass on her passion and knowledge to the next generation of scientist. She has also been awarded with the Priestly medal, which is considered the highest honour in the field of chemistry.

Click chemistry, a concept developed by Barry Sharpless and Morten Medal, revolves around the design of highly efficient and selective chemical reactions for rapid assembly of complex molecules. It was first coined by Barry Sharpless and Morten Medal, revolves around the design of highly efficient and selective chemical reactions for rapid assembly of complex molecules. It was first coined by Barry Sharpless back in early 2000. Its basic idea was to have two molecules that should be able to join or club together to form a bigger molecule. We can easily understand the concept of click chemistry through a seatbelt. Consider the two ends of a seatbelt as to small molecules, and then when you join them, they form a bigger molecule, that is the system containing the two ends of the seat belt, which joined together with a click sound. It is more of a specific spontaneous and robust reaction. Both scientists, working in their own labs, came up with a specific reaction where we use an azide and alkyne. Usually, an adding azide and alkyne together, we get a lot of buy products, but when proceeded with the presence of a Cu(I) ion, it forms a good yield of triazole compound. Click chemistry has found extensive applications in a diverse array of scientific disciplines from drug development to material science to polymers and has streamlined the process of chemical synthesis. Chemical factories have been using this concept in a robust manner and have advanced it to other types too.

People tried using the concept of click chemistry in biological field two, but due to the presence of copper ion which is toxic in nature, they stepped back from doing so. Carolyn Bertozzi, came up with an excellent idea and began working with a complex, Sugar molecule - 'glycan' which is present on the cell membrane. In order to tag any group to a molecule, we have to proceed with sales culture that is provide the molecule with an environment where it feeds on it and then regenerates it to C attached and guide group to the glycan molecule through cell culture. She then used a 'strained alkyne' also known as 'cyclo octyne' attached to a dye. It had a puckered shape, which made it so active that when it was brought close to glycan under feasible conditions, it immediately reacted with it, and then the process of click chemistry continued, but in the absence of the toxicity of copper ions.

It is also known as "metal free click chemistry" and 'bio orthogonal chemistry'. This ground breaking approach involved the creation of chemical reactions that can occur within living organisms without interfering with their natural biological processes. It has revolutionized the study of biomolecules and opened up a new avenue for drug discovery, diagnostics, and understanding of the complex biological systems.

In conclusion, this concept of click chemistry has revolutionized the whole working of chemistry in various fields. This award of noble prize in chemistry is not just recognition but a celebration of humanities unquenchable thirst for knowledge as we witness each year. Stepping onto the world stage, we are reminded that chemistry artists. Heart is a symphony of Human curiosity and innovation, and the noble prize honours those who compose its most beautiful and harmonious moments in future, the chemistry field will take an amazing form and repair the wave for new upcoming innovations. All Times to the outstanding contributions of Barry Sharpless, Morten Medal and Carolyn Bertozzi in the field of chemistry and their transformative research on click chemistry and bio orthogonal reactions, which made them deserving for the honour of the noble prize and chemistry in 2022. They helped us shine a spotlight on the evolving chemistry that shapes our past, present and future.

Physics first price

Spooky action at a distance

Pooja Rath

Podar International School CBSE, Nerul

Oh! This is the right essay indeed, while the title might confuse you. Let me tell you, these where the exact words used by none other than Albert Einstein to describe the phenomenon of quantum entanglement.

In 2022, three Great physicists John Clauser, Alain Aspect and Anton Zeilinger won the Noble prize in physics for their remarkable work with quantum entanglement of photons.

Now what exactly is quantum entanglement? To understand about it, let's go back in time.

When people started taking interest in how things work around us, many scientists came up with various theories, observations and inventions. All these theories provided us with concrete results. We could easily predict the future results. This was known as "classical physics". This branch of physics relied on surety.

As time progressed, scientist started taking interest in atoms and their subatomic particles. While researching scientists found that these subatomic particles had a pretty weird behaviour, their actions couldn't be predicted easily. In order to work with these subatomic particles. Scientist had to take into consideration uncertainty too. This gives rise to another branch of physics known as quantum mechanics, which dealt with randomness and uncertainty. Various mathematical tools like Heisenberg's uncertainty principle were also developed.

Now, in the world of subatomic particles, the particles don't exist in one particular state. Rather, they exist in a mixed state known as superposition. For example, electrons show both up and down spin simultaneously. This superposition is a represented by wave function (psi). But, this is where things get a little complicated. When an electron is observed, it becomes visible in one state. That is the observer collapse. The wave function of the particle. Electrons or any subatomic particle for that matter show another interesting phenomenon known as entanglement. This means that two electrons get paired (entangled) together and their behaviour affects each other, irrespective of the distance between them. So, this means, if we observe the behaviour of one electron of an entangled pair, we can easily predict the behaviour of the second particle of that pair.

It is a given fact that nothing travels faster than light. So, how does the information of behaviour of one electron gets transmitted to the other one instantly? How can the entity travel faster than light?

Making this as their base, three scientists, including Einstein published a paper, which later came to be known as EPR paradox. They concluded that since nothing can travel faster than light, there has to be some variable quantity that facilitate the transfer of information. With this conclusion, they disregard quantum mechanics and called it in accurate and incorrect.

After a few years, a physicist, John Bell became curious about the EPR paradox and started his work on it. He came up with the Bell's inequality that could experimentally account for the variable.

John Clouser, one of the scientists who won the noble prize, decided to experiment on the Bell's inequality. He worked with an a apparatus from a previous experiment. The result obtained led to the conclusion that the assumption of the existence of a variable was Indian incorrect and quantum mechanics was accurate. This statement "spooky action at a distance" about quantum entanglement. John Clouser was one of the first physicists to work on the Bell's inequality and come up with a conclusion.

Even though conclusions were made and the variable theory was incorrect, there were still a few assumptions made by John Bell that closer hadn't worked on. These were considered as loopholes that could still prove the variable theory to be correct. Alain Aspect they decided to work on these loopholes. It included questions like, what if the second pair did not actually show behaviour in accordance with the first particle? What if the experimental set up somehow already chose the reading that went against the variable theory? Alain Aspect conducted experiments by improving the set up used by John Clouser and found results for all the unanswered questions.

The third physicist, Anton Zeilinger worked on quantum teleportation. Here, teleportation simply refers to the transfer of information between two particles. Zeilinger pair or entangled the third photo with one photo which was already entangled with a second photon. This third photon now becomes entangled with both the photons and can transfer information from the first photo to the second one. This concept of quantum teleportation can be used for quantum cryptography. Zeilinger used this concept and performed transmission of information by cryptography for the first time over a distance of 144 km between two islands in Spain.

These phenomenal experiments and findings with quantum entanglement has opened up, totally New World of advancements. The laureates' contribution has led the humanity towards the path of technological development that has the ability to revolutionize our existence.

Misconception about snake venom.

Snake venoms are feared very much as if even touching the venom can kill you. But that is not the case.

Let me describe the level of fear by an example. There was a video which showed a snake biting into a tomato. And then the author (of course very ill informed) said that if you find a vegetable with holes, do not buy them because they may be punctured by a snake and can carry a venom.

Let me state first that this is not true and you do not have to be worried. Let us see how and why.

First and foremost, snake are carnivorous animals/reptiles and they do not try to eat a tomato. They have sense of smell and hence can differentiate between a small animal like frog or rat and a vegetable. Hence, first and foremost they will never bite a tomato.

It is quite possible that a rat or mice is sitting close to the tomato or has rubbed against a tomato, or for some smell by the touch of a human. In which it can mistake the tomato for a rat/mice etc and try grab it. This is highly unlikely.

But even if it does, it will also look for body heat, and blood pressure running in veins. It waits for this circulation to stop to decide on swallowing. Which will be missing in tomato and hence it will bite and leave it immediately, since the snake is mistaken.

Now venom is very precious item. It is released when snake tries to break animal tissue with lot of pressure. Since this pressure is missing in tomato, it will most likely not release the venom.

But even if it does, the venom is is only amines (amino acids) and some proteins. Plants take ammonium from soil and hence know how to neutralize the amines. Hence, this venom will not kill a plant!!!!

Plant is alive and hence will process the amines/proteins and kind of digest this venom.

In animals, venom acts in 3 different ways. There are 3 different categories of venoms. First is Neurotoxic, which effects the neural system or the brain, second, is cardotoxic, which will affect the heart, leading to heart attack and third is hemolytic, which will affect the RBC. Now even for all three types that it is necessary to enter blood system. So if one licks this venom (without any mouth wounds on gums or

cheeks) the venom will be neutralized in stomach which has very low pH. If there is any cuts in gums, then it can come in contact with blood.

So humans or dogs can lick this venom with no effect. And tongue does not get wounds easily. Hence, In Samudra Manthan, when venom came out first, it was snake venom which Lord Shiva could gulp it down with no effects.

Snakes in water do not have any venom. Only land snakes can have venom. This is because snakes try to sense temperature of the prey. In water snakes cannot sense any heat in prey as all are at same temperature. Hence aqueous snakes have no venom.

This can be seen in video:
https://www.instagram.com/drarshtalks/reel/DAJQ-viyNOx/?hl=en

Dr. Shashibhal Pandey

Vice Principal,

Smt. Chandibai Himathmal Mansukhani College

Activity for Students by P.K. Joshi

How Fast are objects in our solar system?

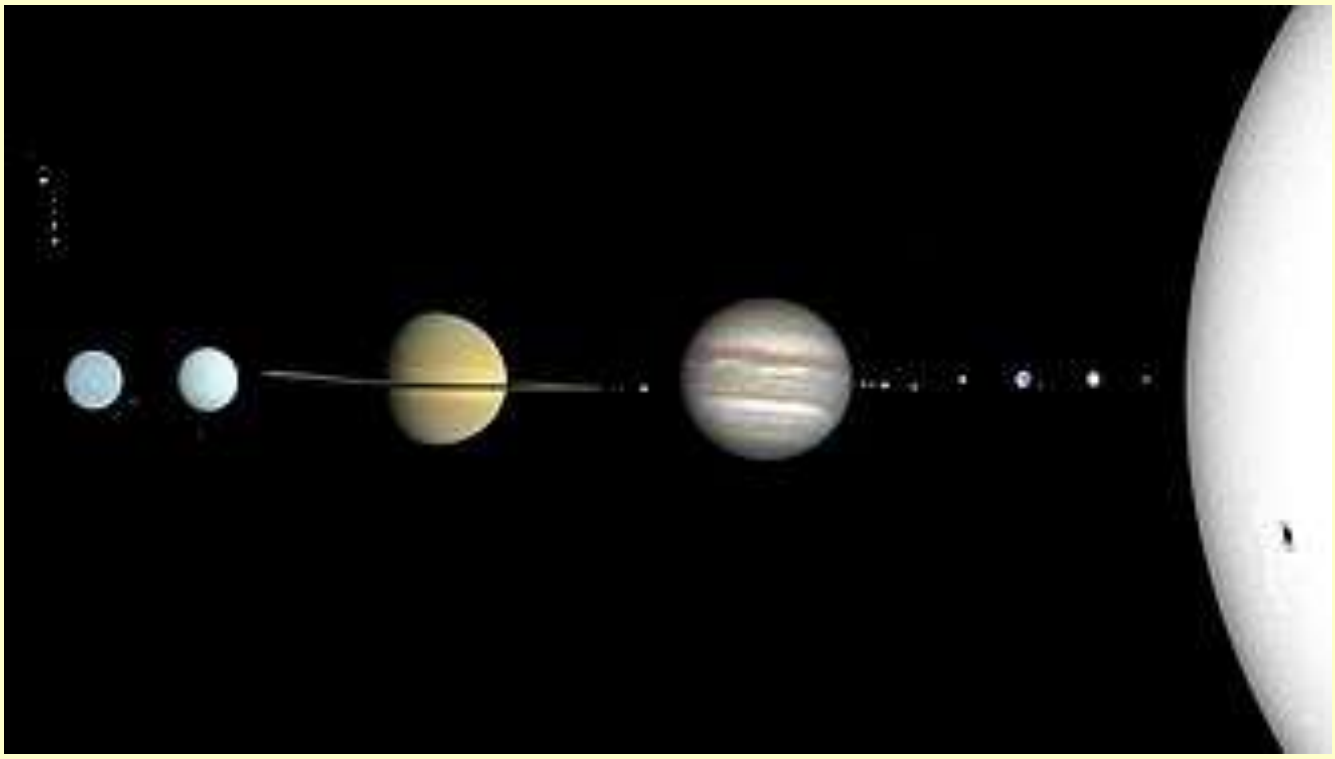
In the previous article we had seen how big is our solar system. Now let us see how fast (or slow) objects move around in the solar system.

You were asked to fill out a table so that the distances compare to a sun of radius 10 cm.

Let us assume that Earth, which is sitting 21.5 m from Sun moves around Sun in 1 minute. Then mercury moves around the Sun in 14 seconds. Scale down all the rotations and revolutions by 365.

It is very interesting to see how fast/slow other planets rotate and revolve around Sun.

Planet	Revolution in minutes	Revolution in units of seconds or hours.	Rotation around its axis in seconds.
Venus			
Mars			
Jupiter			
Saturn			
Uranus			
(Pluto)			
Moon			



Picture from https://en.wikipedia.org/wiki/Solar_System

DON'T MISS IT

Coming up in Next issue (January-March 2023)

1. More about experiments
2. Student's corner
3. Teacher's page
4. Activity question AND MUCH MORE……

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