



Insight

The Brain's Noise Filter

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The frothing and foaming waters of Niagara Falls, one of the greatest waterfalls in the world, are constantly roaring at an astounding 87-95 decibels. That is as loud as a propeller plane flying over your head. Or a lion roaring right at you while you wonder how to escape from the giant cat.

Either way, that's some very loud noise. So how do people living in the surrounding areas go to sleep at night? Same holds for those living next to airports or train stations.

Well that's where our brain's filtering system comes into play. Our brain does something called Sensory Gating which basically filters out any unwanted information. In this way, only the important things get sent over to higher processing centers while unnecessary sensations are filtered out. What's more fascinating is that this process goes on constantly without us even realizing. It holds true for everyone, even those living in quiet places and simply going about their daily lives.

So why is it important to filter out sensations all the time? Shouldn't it be better if we get more information about our surroundings? As a matter of fact, they can be dangerous.

At any given point, all our major senses get so much information that processing all of it can cause someone to lose their mind. Filtering is what protects us from this chaos by maintaining attention on those stimuli which are important.

Researchers have found that one of the primary brain regions involved in this phenomenon is the thalamus. Being a relay center that sits at the junction between our cerebrum and the rest of the nervous system, it decides what all information requires

immediate attention while the rest is either discarded or put on the back burner. However that's simply a small part of the larger picture. Networks of neurons are involved in this phenomenon, some of which are in the hippocampus and the brainstem while others are in the prefrontal cortex of the brain. These regions help shift attention from one object to another, such as focusing on a friend's conversation while ignoring the loud background music at a party.

Our brain is like a well-oiled machine, each cog and wheel serving a great purpose. Even if a tiny piece stopped moving, the entire thing can fall to shambles. A dysfunction in this system can cause mental disorders such as Schizophrenia. The person begins to hallucinate, that is see or hear things that aren't there, or become delusional and withdraw from their friends and family - a frightening scenario faced by thousands in the world.

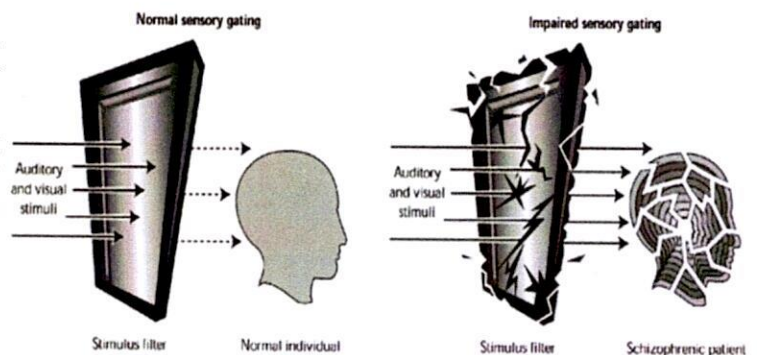


Image credit: Light G. A., Braff D. L. Sensory gating deficits in schizophrenia: can we parse the effects of medication, nicotine use, and changes in clinical status? *Clinical Neuroscience Research*, 2003;3(1-2), 47-54. doi:10.1016/s1566-2772(03)00018-5

Suggested Reading:

- <https://www.psychologytoday.com/intl/blog/brain-babble/201502/is-how-the-brain-filters-out-unimportant-details?amp>
- https://www.huffpost.com/entry/does-the-brain-filter-out_b_9859158
- <https://nuscimag.com/through-the-looking-glass-my-sensory-gating-disorder-77ea0bc65d7>

In The News

Imaging Black Holes

Sharvari Nadkarni Ghosh,

IIT Kanpur.

A black hole is an object that has a very high mass packed into a very small space - as small as you can possibly imagine i.e., infinitely small. This gives it an infinite density and hence an extremely large gravitational field, i.e., the black hole is able to exert a large force on any mass that comes near it, pulling it into itself. Photons are the fastest entities in the universe, but they also get trapped in this field. Thus, this object does not emit light and hence its name. The black hole is so massive that near its centre, the escape velocity (the velocity required to escape the gravitational pull) is greater than the speed of light. However, as one moves further away from the centre, the escape velocity decreases. The distance at which the escape velocity is equal to the speed of light is called the Event Horizon of the black hole. Thus, the event horizon can be thought to be a boundary that separates, the 'seen' and the 'unseen'.

How do we 'see' any object? We see it because of ambient photons that scatter off of the surface of the object are detected by our eye; we do not see in the dark because there is no source of ambient photons. For a black hole, the ambient photons are provided the highly energetic radiation generated by physical processes in the accretion disk - a disk of very hot gas that is orbits around the black hole, further away from the event horizon. As the photon approaches the black hole, the strong gravity of the black hole bends the path of the photon, much like a lens that bends optical light. This process is known as gravitational lensing. The expected signature of the black hole with a thick accretion disk corresponds to a dark patch surrounded by a bright ring.

On 10th April 2019, the team of scientists working on the Event Horizon Telescope (EHT) project announced that they had indeed observed such a pattern around the suspected black hole at the centre of M87, a massive galaxy in the nearby Virgo galaxy cluster. Relativistic effects due to the high speed rotation of the gas in the accretion disk give rise to the crescent shaped arcs observed in the images (see figure 1). By measuring the diameter of the ring and knowing the distance to M87 they computed the mass of the black hole to be 6.5 billion times that of the Sun with an accuracy of about ten percent. Comparing the images to intensive computational calculations gives a lot of information about the physical processes in the accompanying accretion disk.

This is indeed a remarkable achievement - the distance from earth to M87 is a hundred million times

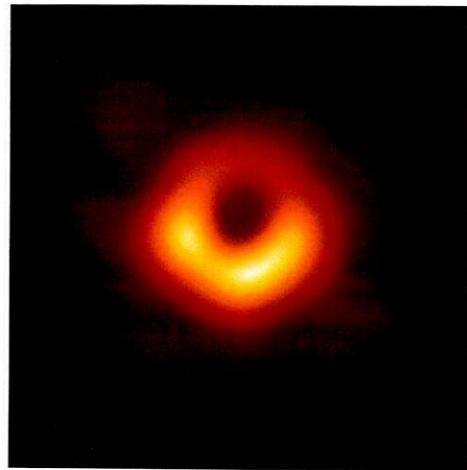


Image of the black hole taken by the EHT.

(<https://www.eso.org/public/images/eso1907a/>)

larger than the diameter of the ring that one would like to detect. This is similar to observing an individual strand of hair from an aeroplane in the sky which is flying at a height of about ten kilometres. The EHT is not one telescope: this feat was achieved using a global network of radio telescopes spread throughout the world, so as to form one virtual Earth-sized telescope. This idea is more technically called Very Long Baseline Interferometry or VLBI. Incidentally, another way of detecting a black hole is to examine the motion of the stars around a suspected candidate. In 2008, the research group of Andrea Ghez, confirmed the presence of a supermassive black hole at the centre of our own Milky Way in the bright region known as Sagittarius A*. Both these discoveries agree with the hypothesis that the centre of every galaxy hosts a supermassive black hole. Its surrounding central region is called the Active Galactic Nucleus (AGN), in analogy with the nucleus of a cell, which is more than a billion billion times smaller.

Through The Lens

*Josette Misquita, TYBSc Life Sciences,
St. Xavier's College - Autonomous, Mumbai.*



Can you identify this insect that is known for its loud chirping sound?

Science In Daily Life

New(ro)Marketing

*Aayush Khanna, TYBMS,
St. Xavier's College - Autonomous, Mumbai.*

Recently, Instagram came up with this tab called 'Your Activity' which tells the users their average daily usage of the application. It was only then that people realised how they were wasting around 2 to 3 hours on only one social media app daily. Are you one of those who wonder how you open up one of these social media apps for just a minute but end up spending hours in one go? Well if you are, then we have an answer here! These social media companies such as Facebook and Instagram have based their user interface on an experiment called Bottomless Bowls (2005 Jan; Wansink B and Painter JE), where 54 subjects were served soup in self-refilling bowls without their knowledge, and the result- they ended up consuming 173% of the normal quantity of the bowl !! Using this conclusion, these apps give the user an endless scrolling facility, thereby keeping the consumers engaged.

This was one example where companies are playing with people's brains to earn profits and believe it or not, this isn't the only one. Businesses have started using these neuroscience techniques to predict consumers' behaviour, thereby giving birth to Neuromarketing. Simply stated, Neuromarketing unfolds how a consumer's subconscious brain reacts to the stimuli to take a decision. To study this, one needs to understand how different parts of the brain works. For the purpose of Neuromarketing, there are figuratively three parts of the brain: 1. The New brain which gives logic and rationale; 2. The Middle brain which feels and emotionalises; and 3. The Old brain which takes decisions on the basis of the inputs from the two other parts. This means that it is the old brain which marketers need to tap and control.

According to Patrick Renvoise, an expert on the subject, there are Six Stimuli which impact consumers' behaviour starting with the 'ME' Factor, which tells the marketers to talk less about their company and more about the consumer. This is the reason you'll see companies selling the benefits of you being fair rather than the features of the fairness cream. Next comes, Contrast. The old brain catches the vivid difference between comparable items very quickly. Contrast allows the old brain to make quick, risk-free decisions. Now you know why Sanjeev Kapoor was washing clothes with both Ariel and 'Normal Detergent' on your TV screens. The third one is 'The Tangible Input' which simply means that the old brain recognises only what is simple, familiar, and tangible, or else it gets transferred to the new brain, thereby delaying the decision making process. Hopefully, our textbook authors will understand this one day! Ever heard "The first impression is the last impression"? Well, the next stimulus is what talks about the old

brain recalling only the opening and finale of an event and overlooking the in-betweens. This is why some Youtube ads deliver their main messages before the user gets the 'Skip Ad' option. The fifth stimulus is called 'Visual' and as the word states, it refers to using more visual elements than words in putting marketing efforts. Hence, it is rightly said, "Jo dikhta hai, wohi bikta hai". Think of the last print advertisement you loved, wasn't it a 'visual'? Lastly, we have the stimulus of which neurobiologists have been trying to explain the scientific angle to the world. Well, it's called Emotion -- an electrochemical transmission for the neuroscientists, but a competitive opportunity for the marketers. You related to that advertisement strongly, well that was just a marketing technique you got triggered with.

Neuromarketing is not just a post-purchase observation. It includes a whole set of experiments which are conducted before even releasing an advertisement in the market. Processes like fMRI, Electroencephalography (EEG), Positron Emission Tomography, facial coding, and eye-tracking are used to learn how consumers respond and feel to different stimuli.

In conclusion, this 'new' marketing has been trying to tap on the source of 95% of our brain activity - the subconscious mind, and if our response pattern is set to be studied, it is succeeding with flying colours. Did you just think of a rainbow? That's how Neuro-marketing works!

Sources: <https://conversionxl.com/blog/old-brain-stimuli/>

Stimulate Your Grey

*- Antara Raghvi, Class IX,
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Baobab trees are mainly found in arid areas of Madagascar and mainland Africa (though there are 120 of them in Mumbai!). They are thought to be thousands of years old, and are often called the oldest flowering plants. But this is rather difficult to verify due to a structural difference when compared to other species of tree. What is this difference ?

Long, Long Ago

Monkey see, Monkey do

Deepika Jauhar, MSc Life Sciences,
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Long ago, in evolutionary time, a special feature that makes us human evolved. Some special neurons came up that gave us the ability to empathize. What do we mean by empathy and how does it make us who we are?

You are playing dodgeball with friends and you see a friend getting smacked in the face with the ball, does your own face recoil as if you have been hit? When you see someone smile at you, without thinking you smile back. Ever noticed how your face grimaces when you see someone else eat a lemon? Why does this happen? Why do you end up copying others' actions? This unconscious mimicking of other people's facial expressions and body movements is something brought about by a special neuronal network in your brain. The neurons involved in this network are aptly called as mirror neurons. As the name suggests, they help coordinate the necessary movements for such actions. Some facts about mirror neurons:

- First discovered in Macaque monkeys. They are found only in primates.
- They are responsible for making you yawn after you see someone else yawn.

•This is not their only job, they coordinate these same movements when you are consciously making them (not mimicking others!).

The question arises, why do we need such mimicking behaviour? It helps us learn, helps us empathize with others. Humans, being social animals, need this form of behaviour in order to understand one another and interact with each other. Infants, children, learn how to perform basic actions by imitating their parents and others around them. Mirror neurons play a crucial role in childhood development and forming relations with others around us. It is easier and faster for us to learn by observing someone, rather than by explanation. Think about it, would you be able to learn how to swim by just being told how to, or by observing how to swim as well. Now knowing that it is important and crucial for our social behaviour and learning, what would happen if something goes wrong in this circuitry? Autism Spectrum Disorders (ASD) and Psychopathy have been linked with irregularities in the mirror neuronal network. (However it doesn't mean that the mirror neurons are solely responsible for these conditions, it simply is one of the many things that lead to either of the conditions.) Psychopathic people are unable to empathise with people, despite understanding emotions. They are able to react back to people, but actually fail to truly understand other people's feelings. In ASD, the children cannot understand others expressions, they are unable to empathize and react back. This results in poor relationship skills which is a characteristic trait of ASD.

Thought Byte

"We would be worse than we are without the good books we have read, more conformist, not as restless, more submissive, and the critical spirit, the engine of progress, would not even exist. Like writing, reading is a protest against the insufficiencies of life. When we look in fiction for what is missing in life, we are saying, with no need to say it or even to know it, that life as it is does not satisfy our thirst for the absolute – the foundation of the human condition – and should be better. We invent fictions in order to live somehow the many lives we would like to lead when we barely have one at our disposal."

-Mario Vargas Llosa, Nobel Prize in Literature 2010.

Answer: Through the Lens - Teleogryllus Emma(cricket). The loud chirping sound made by Male crickets is known as stridulation. (They rub the upper and lower parts of their wings together). It is a call to attract the females. The females have an ovipositor that helps them lay eggs in organic matter.

Answer: Stimulate Your Grey- They lack growth rings.

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SPECTRUM

WIVES OF SCIENCE



ISSUE NO : 5

In The News

A Genius Has Left Us

Shyamala Bodhane,

St. Xavier's College - Autonomous, Mumbai

The world lost the Icon of the century, Stephen Hawking, on March 14, 2018. A British scientist, Stephen Hawking, professor and author, was born on 8th January, 1942, in Oxford, UK. Stephen, as a schoolboy, was a bright but not an exceptional student. Enjoying the company of his friends, he showed creativity in designing different games, models of airplanes and boats. Inspired by a Mathematics teacher he, along with his friends, built a computer from clock parts, an old telephone switchboard and other recycled components.

He acquired a BA degree, with first class, in natural science from University College, Oxford. In 1962, he joined Trinity Hall, Cambridge, for studying Cosmology. In 1963, at the age of 21, he was diagnosed with motor neuron disease. The nerves that controlled his muscles were shutting down. He was then told that he had just 2 years to live. The disease progressed slower than predicted by the doctors. Also, the love of a young girl friend, Jane Wilde, prevented him from going into complete depression. With the encouragement of his teacher, Prof Dennis Sciama, Hawking started working for his PhD.

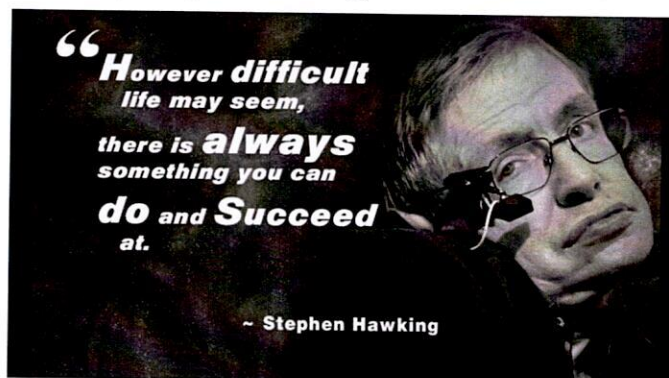
The Big Bang model says that the universe emerged from an extremely hot and dense state, like a compressed gas. (Hartle and Hawking proposed that before the big bang, time did not exist; so the universe had no 'beginning'.) From there it expanded, cooled and kept becoming less dense overall. But the cooling also gave rise to matter and, because of gravity, to star formation. A massive star can literally collapse. This happens when it exhausts its nuclear fuel and cannot generate gas pressure. Gravity forces it to contract. As it squeezes itself beyond the Chandrasekhar limit, gravity becomes so strong that even light cannot come out. The star becomes invisible, a *black hole*. Can nothing escape a black hole? No. Hawking showed in 1974 that according to quantum mechanics, black

holes are not entirely black. They must emit a form of radiation, known as Hawking radiation, which makes them lose all energy until they eventually vanish.

The Indian physicist A. K. Raychaudhuri formulated a mathematical equation that paved the path for work that led to the powerful Hawking-Penrose singularity theorems that proved the inevitability of black holes. Work by C. V. Vishveshwara, popularly known as the 'black hole man of India', contributed to the recent detection of black holes through gravitational radiation. In science, the building up of knowledge is collaborative. The final celebrated outcome is after many wise minds have thought hard about the same problem from different points of view.

Professor Stephen Hawking had thirteen honorary degrees and was awarded a number of prestigious prizes. Books written by Hawking helped to make science accessible to everyone. Hawking's first book, *The Large Scale Structure of Space-Time*, written with George Ellis, was published in 1973. For a popular audience, he wrote the best-seller *A Brief History of Time* in 1988 and *The Universe in a Nutshell* in 2001. In 2007, Hawking and his daughter Lucy published *George's Secret Key to the Universe*, a children's book designed to explain theoretical physics in an accessible fashion.

At the turn of the century, he and eleven other luminaries signed the *Charter for the Third Millennium on Disability*, which called on governments to prevent disability and protect the rights of the disabled.



Insight

What's in a Name?

Katie Bagli,

Freelance Story Writer.

Naming a new-born generally sends all the family members into a tizzy referring to the astrological correctness or going through atrociously long lists of names, and what have you. But let us step into the animal and plant kingdom. It may interest you to know the names of some of our flora and fauna, their origins and their implications.

For instance, there is this bird commonly called Wry-neck which may have been so named as it has a comical way of stretching its slender neck and beak upwards and moving its head from side to side when it is surprised or frightened or under stress. The torque which it brings about upon its own neck led a scientist to name it *Jynx torquilla*. And that is how the word 'jinx' came into use.

When we talk of someone being a 'sniper' we mean one who can shoot slyly at long range from a hiding place. A sniper could also be one who makes a sly or petty verbal attack. This is because long ago it was considered a sport to flush out the Painted Snipe birds from their home - the reeds - and shoot at them. Unfortunately for the bird, they were an easy target as they have a slow flight.

The Stone Curlew bird, in my opinion, got its name because of its staring, unblinking, stony yellow eyes. But it has also got another rather unflattering common name - Thick-knee. The poor bird has all the grace of a ballerina with its long slender legs, but for the knees that are absurdly thick!

The delectable chocolate which young and old, all enjoy and find irresistible, owes its popularity to the cocoa tree *Theobroma cacao* of Central and South America. 'Theobroma' in Greek language means the food of the Gods. The Aztec tribes of the plant's native country made beverages and all kinds of 'heavenly' concoctions out of its seeds. In fact, the cocoa beans were even used as currency, so valuable they were considered to be. Much later Switzerland, where ironically these trees did not grow, mixed cocoa powder with milk and began producing chocolate.

The Jungli Badam tree - tall, imposing and rather attractive when, after having shed all its leaves, it sprouts tiny star-like blossoms - has been given the scientific name *Stercula foetida*. The genus name *Stercula* was adopted from the Roman god of manure and dung and the species name *foetida* to reiterate the fact that you may want to cover your nose when passing by it. Indeed, its beautiful flowers smell unpleasantly foetid.

The reason? Nature has a reason for everything. The rotting smell attracts flies - its pollinators!

Thus, one can go on and on, the list is endless. But having gone through it, do you believe the name of a being lends a certain character to it? Or are you one of those who believe a rose is a rose, call it by whatever name?

Science In Daily Life

Sleep: An Unsolved Mystery!

Shriya Pai and Nidhi Solanki

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As we know everyone needs to sleep and we spend about one third of our life just sleeping! Interestingly, though we appear inactive and immobile, our brain and body stay remarkably active while we sleep. While scientists are now beginning to understand what happens in our brain during sleep, a lot more questions emerge. Before we address some of these questions, here is a brief introduction to a simple but interesting aspect of sleep -- a sleep cycle. If you carefully watch a sleeping friend you can easily identify two major stages of sleep : one in which the eye ball in moving under the closed eyelids , the Rapid Eye Movement or REM sleep and the other when no such movement of eyeballs is happening, the Non REM sleep. Each sleep cycle has REM and Non REM states of sleep and here is what really happens.

NON-REM Sleep is the period of sleep where you start feeling drowsy due to decreased metabolic activities and reduced blood pressure. Your muscles seem to be most relaxed and you head towards your deep sleep. Non REM sleep is further classified into three different stages.

The Stage 1 of Non-Rem sleep is a short period of light sleep. As wakefulness changes to sleep, our heartbeat, breathing and eye movement slow down. Muscles too relax though occasional twitches occur. Slower brain waves can be recorded during this sleep as compared to wakefulness.

The Stage 2 of Non-REM sleep is a period just before setting in of deeper sleep. The heartbeat and breathing are slow. The muscles relax even further and the movement of the eyes stops. . Interestingly, there is a drop in your body temperature too. Bursts of electrical activity marks this stage, though the brain waves are still slow. You spend most of our sleep time in this stage as sleep cycle is repeated.

The Stage 3 Non-REM sleep is the period of deep sleep. The heartbeat and breathing is at their lowest levels with muscles so relaxed that it may be difficult to wake up. Slow brain waves are recorded during

this stage. This is the part of the sleep cycle that occurs during first half of the night for long periods.

REM sleep: This is an interesting part of your sleep with lot of activity in the brain similar to what is record from the brain when you are awake. Eyes move from side to side behind closed eyelids, rapidly. The heart rate and blood pressure increases, accompanied with faster breathing. You dream mostly during REM sleep and sometimes in non-REM sleep as well. Limb muscles become temporarily paralyzed during this stage so that you can never enact your dreams!

Both REM and non-REM sleep contribute to a good sleep. Have you ever wondered that sleep is such a complicated thing? Just think, why do we even sleep? Why do we get a feeling that we are falling from a cliff in our sleep? Why do we sleepwalk or bedtalk? Why salivation takes place during sleep? Why do we dream? Why do the elderly sleep less? So many questions need to be answered, a challenge for neurobiologists! Though some questions do have answers, sleep is indeed a mystery waiting to be solved.

www.webmd.boots.com/sleep-disorders/guide

<https://www.livescience.com/32469-why-do-we-sleep.html>

Stimulate Your Grey

Guess What ?

Here are the national flags of Australia, Papua New Guinea and New Zealand.

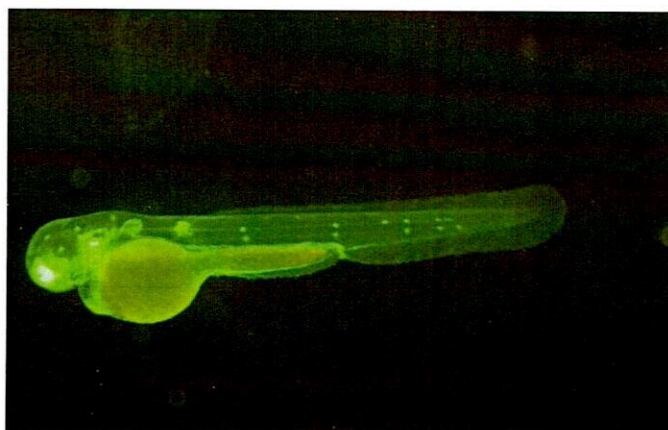


All show a constellation of stars. It is the smallest of the 88 constellations, but one of the most prominent constellation in the southern sky. It has helped navigators in the southern hemisphere for centuries to find their way around. We can technically see it from Mumbai at some times of the year, but it is almost impossible because of the light polluted skies, especially near the horizon.

What constellation is this?

Quiz courtesy Dr. Arnab Bhattacharya

Through the Lens



A fish paint to understand biology : This is a two day larva of zebrafish with its parts fluorescing green. The green fluorescence is because this fish has a gene that makes the green fluorescent protein (GFP) attached to one of its own genes (let's call it X) so that wherever 'X' protein is made the GFP will also be made and appear green when seen under an ultraviolet light. In this fish the tiny green dots you see are sensory hair cells which help the fish sense water movement.

Image courtesy Dr. Yasmin Khan, Sophia College, Mumbai.

Long, Long Ago

Indigo – The Dye To Die For

Gail Carneiro

Associate Professor (Retd) Sophia College, Mumbai.

The colour 'blue' evokes feelings of calm and peace in us, reminding us of the sky and the sea. A world with no blue fabrics or objects would be hard to imagine. However, prehistoric man had only reds and yellows from flowers and other vegetation to colour his attire until he discovered indigo, the third primary colour, from the plant genus *Indigofera*. Archaeologists have found seeds of the Indigo plant and pieces of cloth dyed with indigo at excavation sites of the Indus Valley civilisation. Indigo was one of the most valuable commodities traded by the people of the Indus valley, first with other early civilisations and later with Europe. It became so famous that the Greeks called it 'indikón' or colour from India and it was such a prized trading commodity that it was referred to as 'Blue Gold', a regal colour. The extraction process of indigo from the plant was both tedious and complicated but was a closely guarded secret handed down from generation to generation.

Export of indigo from India to Europe from the 16th

century was so lucrative that peasants of Bengal were forced to grow the indigo plant at the cost of much needed food crops leading to food shortage and much suffering. A peasant revolt in 1859-60 virtually halted indigo production and export from India. In 1878, Adolf von Baeyer, a German chemist discovered a synthesis of indigo and the much cheaper synthetic dye quickly replaced natural indigo. Later, during World War I, German synthetic 'indigo' was not available and export of natural indigo from India became profitable once more. Poor tenant farmers especially in Bihar, were forced by the terms of their tenancy to grow indigo subjecting them to untold suffering including food shortage. This moved Gandhiji to lead them in the Champaran Satyagraha of 1917 which besides ending the exploitation of the farmers had far reaching consequences for the power of satyagraha and the nationalist movement.



Indigofera and a piece of indigo plant dye from India
https://en.wikipedia.org/wiki/Indigo_dye

Later, commercial dyeing started using synthetic indigo almost exclusively. Indigo, once a luxury dye for royalty was now used extensively to dye 'blue jeans' a symbol of the common man and produced in great quantity. However, increased awareness of the toxicity and environmental pollution associated with synthetic dyes and intermediates led to a renewed interest in natural dyes and indigo plantations started in parts of Bengal and south India. Although cultivation, extraction and processing of natural indigo is costly, it has become popular as it is safe and natural and no new synthetic alternative can match the aesthetic beauty of hand-dyed natural indigo.

Answer to quiz

Put one red marble in jar 1, and the other 99 in jar 2

Probability of finding a red marble in jar 1 = 1

Probability of picking jar 1 at random = 0.5

Therefore probability of finding a red marble and picking jar 1 = $1 * 0.5 = 0.5$

Probability of finding a red marble in jar 2 = $49/99$ (Number of red marbles/total number of marbles) = 0.4949

Probability of picking jar 2 at random = 0.5

Therefore probability of finding a red marble and picking jar 2 = $0.4949 * 0.5 = 0.2474$

Total probability of picking a red marble at random = (Probability of picking a red marble in jar 1) + (Probability of picking a red marble in jar 2) = 0.7474

And this is the highest probability of all the arrangements.

Thought Byte

"It is interesting to contemplate an entangled bank, clothed with many plants of many kinds, with birds singing on the bushes, with various insects flitting about, and with worms crawling through the damp earth, and to reflect that these elaborately constructed forms, so different from each other, and dependent on each other in so complex a manner, have all been produced by laws acting around us.

Thus, from the war of nature, from famine and death, the most exalted object which we are capable of conceiving, namely, the production of the higher animals, directly follows. There is grandeur in this view of life, with its several powers, having been originally breathed into a few forms or into one; and that, whilst this planet has gone cycling on according to the fixed law of gravity, from so simple a beginning endless forms most beautiful and most wonderful have been, and are being, evolved."

— Charles Darwin, *The Origin of Species*, 1859.

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