Gloriosa

Vol.: IV
(2023- 2024)

The Science Magazine
Department of Botany

Scottish Church College

NEC TAMEN CONSUMEBATUR

Featuring

➢Women in Botany

➢Knowing plants of our platters

➢Botany and beyond

➢Beverages: all botanicals

➢Information and knowledge testing pages on 'Botany'

Gloriosa

THE SCIENCE MAGAZINE

Department of Botany

Scottish Church College

Volume IV (2023-24)

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Preface

Dear Readers,

Since its inception in 2010, Gloriosa has been a part of Botany department, Scottish Church College. After the publication of the third volume in 2022, the current volume remains to be a fresh compendium of scientific articles contributed by stakeholders of the department. The fourth volume commemorates Lt. Ms. Nivedita Guha Roy, as we could feel this was an apt opportunity to offer homage to our very dear student. The volume encompasses summary of activity of gloriosans, followed by a series of articles on the contribution of a few eminent female botanists in the field of plant science research. Thereafter, the volume is divided into parts that focus separately on plants that are highly consumed, plants used as beverages, miscellaneous articles and finally a student friendly interface of websites, research institutes and quiz exclusively on plant science. We believe that the magazine, in its current form, would be elemental to grow interest of budding botanists to learn and apply the benefits of plant science. Also, the tradition of Botany department would cater to the teachers, alumni and research scholars in form of this very humble effort. We hope our magazine will be admired by readers from botany as well as from different other backgrounds.

Scottish Church College
(A Christian Minority Institution)
Parent Body: Church of North India
NAAC Re-Accredited Grade 'A' Institution (3rd Cycle)
Ranked 88 in NIRF 2024

Estd. 1830

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Message from the Secretary

I have great pleasure in extending my best wishes and appreciations for the publication of the magazine Gloriosa by the teachers and students of the Botany Department of this college. The current issue is a commendable effort by the department to bring together activities and achievements of students and teachers.

I am happy and excited to affirm various educational and innovative endeavours of the teachers and students which will surely enable significant opportunity to study plant world in coming years.

I wish Gloriosa to prosper and encourage budding botanists of this college.

Dr. Swapan Kumar Mukhuty
Secretary
Scottish Church College Council.

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Principal
email: principal@scottishchurch.ac.in

Message from the Principal

Gloriosa has been the tradition of the department of Botany since its inaugural issue in 2010. As a member of the same department, I relate to the excitement of capturing and commemorating our department's unforgettable moments and achievements through this magazine.

I am delighted to share that Department of Botany along with the Department of Chemistry have been awarded the prestigious DST-FIST grant in 2023 for the next five years. This accomplishment is a testament to our ongoing commitment to teaching and innovation. In recent time the college is NAAC Re-accredited Grade 'A' institution (3rd cycle) and ranked 88 in NIRF 2024.

This year's edition of Gloriosa provides a comprehensive overview of our department's activities, student profiles and their creative contributions. It also reflects the sentiments of our alumni and celebrates the scientific endeavours of our current students. I am confident that Gloriosa will continue to inspire future generations at the Scottish Church College's Botany Department, encouraging them to engage in organized activities and embrace academic challenges beyond the boundaries of knowledge.

Congratulations to all students, teachers and non-teaching staff who have contributed to the success of Gloriosa 2024. Your dedication and hard work have made this publication a significant milestone for the department.

Warm Regards,

Madhumanjari Mandal
Dr. Madhumanjari Mandal
Principal

23/8/24

Principal
Scottish Church College
Kolkata

Message from the Vice Principal

Some time back, NASA unveiled an image of galaxy cluster that covers a patch of sky approximately the size of a grain of sand held at arm's length by someone on the ground -revealed thousands of galaxies in a tiny silver of vast universe. If this is a wonder of Nature, a global consumer culture is the destiny of man. We perhaps need to strike a balance. Only material success cannot be the sole parameter in our life. This is where a Little Narrative, side by side with the Grand one, intriguingly matters. The news of the coming out of a subsequent number of *Gloriosa* -the Departmental Magazine of Botany-makes me delighted. Any such magazine is not only interactive by nature but at the same time creates a space that transcends the barriers of the local and hold the possibilities of a global. I warmly congratulate the students and wish them all the best.

Suprotim Das

Vice-Principal

20-08-2024

Message from the IQAC Coordinator

It is indeed a delight to know that Department of Botany is coming up with yet another edition of Gloriosa-the recurrent departmental magazine. I feel extremely proud of the department for continuing with this noble initiative for the students. This will give the students a platform to express their views on the recent development in the field of plant sciences, share memories in department, jot down scientific activities and also cater to boost the scientific acumen of the newcomers in the department.

The department has always given such opportunity by encouraging the students to give seminar talks and participate in conferences. I thank all the faculty members and the students of the department of Botany for this initiative and wish them all the best in their endeavour.

Dr. Samrat Bhattacharjee

IQAC Coordinator

20-08-2024

Message from the Head, Dept. of Botany

We are what our thoughts have made us. So take care about what you think. Words are secondary. Thoughts live, they travel far.

-Swami Vivekananda

It is our immense pleasure that we are going to publish the 4th issue of Departmental magazine 'Gloriosa'. In this magazine students, faculties and alumni members of Botany Department could express their innovative ideas and thoughts. Sincere thanks are due to Dr. Srijita Ghosh and Dr. Biplab Kumar Bhowmick, the joint editors, for their tireless hardwork for publication of this current issue of the magazine.

May Gloriosa prosper and flourish more in coming years by the grace of God.

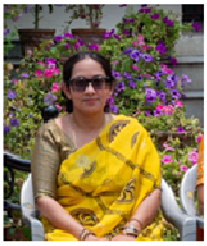
Rajyasri Ghosh
Head, Department of Botany

CONTENTS **Page no.**

People who claim that 'Teaching and Learning' Botany at Scottish Church College has been the most wonderful job in life

Dr. Amitava Roy

Dr. Rajyasri Ghosh



Dr. Srijita Ghosh

Dr. Nilanjan Chakraborty

Dr. Satabdi Ghosh

Dr. Biplab Kr Bhowmick

Ms. Camellia Nandi

Dr. Shuvadeep Majumdar

Dr. Sukanya Chakraborty

The 'Behind the curtain' people in our labs..

Ravi Da, Manoj Da, Mihir Da

Rajib Da, Swapan Da, Madhai Da

We, the Gloriosans

Prof. Binay Chaubey, Dept. of Botany, University of Calcutta, receiving blessings from Retd. Prof. Swapna Das, Dept. of Botany, Scottish Church College

Dr. Madhumanjari Mandal, Principal, Scottish Church College, with Retd.Prof. Kalyan Kr. Mandi, ex-Principal, Scottish Church College

अस्मदाचार्य पर्यन्ताम् वन्दे गुरु परम्पराम् ॥

Glimpses of the tradition of Guru-Shishya at our department..

Dr. Amitava Roy, present faculty, with his teacher and ex-faculty, Dr. Kasinath Ghosh and the recent alumni behind, all engaged in active research

We, the Gloriosans

Dr. Shampa Bhattacharyya, ex- faculty and alumnus, with her dear students

Dr. Swagata Basu, speaking with the people at 14th reunion, (Canopy)

अज्ञानतिमिरान्धस्य ज्ञानाञ्जनशलाकया ।
चक्षुरुन्मीलितं येन तस्मै श्रीगुरवे नमः ॥

Glimpses of 14th Reunion, Canopy, held on 07.10.2023

We, the Gloriosans

Moving from Aspirations to Inspirations

Aliviya Sharma

Nehan Shamim

Sambuddha Talukdar

Anuron Banerjee

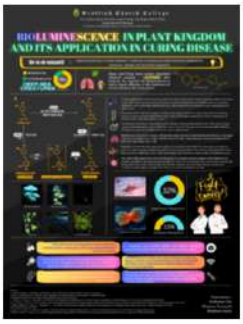
Gloriosans, congrats!!

Antara Rakshit

Antara Rakshit

A few moments to cherish..

1st Position in One Day National Seminar, Poster Presentation and Photography Competition , Dinabandhu Andrews College, participated by Sem 3 UG batch (2023) (Shinjinee Pramanik , Anshuman Jha, Shubham Dutta)



1st Position Celebration of World Science Day for Peace and Development, Ramakrishna Mission Vivekananda Centenary College, particpated by PG Sem 4 batch (2023)on 12th Nov, 2022 (Sayani Nag, Sumeddha Chanda, Sunandana Das, Akshita Tiru)

Poster winners at National Symposia held in University of Burdwan and University of Calcutta, participants: PG Sem 4 batch (2024), Deblina Jana, Ishita, Debadrita Dutta, Arnab Adak, Pratyusha Singha, Peuli Khanrah, Sarthak Dey, Shreya Ghosh

We..in research communications

Biotic and abiotic stress tolerance through CRISPR-Cas mediated genome editing

Journal of Plant Biochemistry and Biotechnology

Plant Stress

Twin effects of fungal elicitor produced from *Alternaria alternata* on induced systemic resistance and secondary metabolites production in *Catharanthus roseus* (L.) G. Don

Anamika Paul, Nehan Shamim, Krishnendu Acharya, Nilanjan Chakraborty

KAVAKA 58(1):33-39(2022) doi:10.36460/Kavaka/58/1/2022/33-39

A world review on the genus *Trichoglossum* (*Geoglossales*, *Ascomycota*)

Disha Dasgupta, Ashita Baishkhiyar, Nilanjan Chakraborty*

Department of Botany, Scottish Church College, Kolkata-700006, West Bengal, India.

**Corresponding author Email: nilanjanchak85@gmail.com*

(Submitted on December 21, 2021; Accepted on March 04, 2022)

ABSTRACT

Caryologia

Firenze University Press

Unfolding chromosomal uniqueness of the Scilloid ornamental *Albuca virens* by application of EMA based Giemsa- DAPI staining

Review Article

Ethnopharmacological Potential of Phytochemicals and Phytogenic Products against Human RNA Viral Diseases as Preventive Therapeutics

Anamika Paul, Nilanjan Chakraborty, Anik Sarkar, Krishnendu Acharya, Anuj Ranjan, Abhishek Chauhan, Shilpi Srivastava, Akhilesh Kumar Singh, Ashutosh Kumar Rai, Iqra Mubeen, and Ram Prasad

Remembering Nivedita Guha Roy

Nivedita Guha Roy (born 30.10.1992), was a dear Post Graduate student of us in the 2015-2017 batch. As a student, teachers were fond of her and as a person, she won hearts of all her batchmates. Her academic background and science skills were appreciated in all four semesters of PG course. It is with deep sorrow that we lost her as a consequence of a fatal fever.

In the vibrant corridors and tranquil gardens of our college, Nivedita's presence was a constant source of light and joy. Her laughter filled the hallways, bringing smiles to everyone around her. As we reflect on the moments we shared, we appreciate the profound impact she had on all of us, particularly within the Botany department.

Nivedita was not just a classmate; she was a dear friend, a confidante, and an inspiration. Her passion for the study of plants and the natural world was infectious, often encouraging those around her to aim higher.

Her kindness and empathy were boundless. Nivedita had an innate quality to make everyone feel appreciated and understood. She maintained a positive attitude in every situation, a

quality that endeared her to both friends and faculty. Many of us recall the numerous times she offered her help, whether it was with academic challenges, grasping complex botanical concepts, or personal struggles. Her support was always heartfelt and unwavering.

Beyond the classroom, Nivedita was an integral part of our college community. She was a passionate participant in our department's botanical excursions, sharing her extensive knowledge of flora and her excitement for discovering new plant species. On our college outings and field trips, Nivedita was always eager to explore diverse ecosystems, turning every excursion into a memorable and educational experience.

One of Nivedita's most admirable traits was her resilience. She faced challenges with grace and determination, never letting setbacks dampen her spirit. Her strength was a beacon of hope for many of us, reminding us that with perseverance and a positive outlook, we can overcome any obstacle. She often drew parallels between the adaptability of plants and our own lives, inspiring us to be resilient.

As we say goodbye to our dear friend, we carry forward her legacy of kindness, passion for Botany, and resilience. Nivedita's memory will continue to inspire us to be better, cherish each moment, and support one another as she did. Though she may no longer be with us, her spirit lives on in the hearts of all who knew her and in every leaf, flower, and tree that she loved.

Rest in peace, Nivedita. Your echoes will forever resonate within these halls, reminding us of the beautiful soul you were and the indelible mark you left on our lives and the Botany department.

- Ram Arnab Sen

Nivedita was a free, open-minded, friendly girl and a very close friend. We were unaware that we shared the same hometown Asansol by birth until we met with each other during our master's at Scottish Church College in the Department of Botany. We had a great time together not only during our time in Scottish and also outside the college hanging out with a lot of other friends. Apart from that, we enjoyed our time travelling together on our departmental excursion to Sikkim, Gangtok. Despite having a completely different personality and perspective, we bonded very well with each other. We used to have a very healthy, engaging and interactive discussion about different conceptual topics in Botany. After we graduated with our master's, we met 3-4 times outside college where we had a lot of fun as always. Later, when l came to know about her unfortunate and accidental demise, l couldn't even believe that at all, l was very upset and devastated. After a few days, l had to recover from that feeling as life moved on anyway. Above all, she will be in our hearts and minds forever with all her great qualities and kindness, and l will always remember her with all the joyful memories spent with her. -Retwika Ganguly

Close friends are one of the most precious people in our lives. Nivedita was one of them.The memories we made together will always hold a special place in my heart. Your kindness, loyalty and willingness to always be there for me have been a true inspiration. Nivedita's kindness, loyalty and willingness to always be there for me have been a true inspiration. No one talked to me on the 1st day of college in Scottish. Only she spoke to me. After some days Deboleena became a friend of mine. We were 3 best friends. We were 3 musketeers. We had many good memories. Nivedita also came to my wedding. She was such a good person, everyone in my house fell in love with her. Her death is very painful for me. I can't express

my feelings. Only I can say that people like her are rare in this world. I can never forget the memories. Rest in peace " Bondhu ". We'll forever miss you. -Soma Brahma

I met her as ‘one of the student’ in the PG course in my first batch of students in 2015. She was never a book nerd and had little mischief in her baggage always. She joined me for her PG dissertation work on DNA fingerprinting of moong beans. It was entirely to my surprise that I discovered a sincere, scientifically rational and prompt Nivedita. Her work still has been an example of a good project to current students. Her consistency and sincerity made a mark in the department and she was definitely ‘one of those students worth remembering’. Later she joined as a faculty in private institute and probably could make a good teacher or a scientist if life had left some more years. I saw her help her fellows even out of her limitations. We all wish her should to rest in eternal peace.

- Dr. Biplab Kumar Bhowmick

Part I Women in Botany- Aritra Das, UG Semester VI

Jeanne Baret

In the middle of a drab concrete jungle of grey, a thorny vine, almost like the gnarled fingers of a century old tree unconcerned with order, gives rise to a riot of colour. The tiny true white flowers hide behind their showy bracts of fuchsia, fiery orange or magenta. It braves the harshness of the sun and the dryness of the land and is a testament to the sheer creativity of mother nature. It is the humble *Bougainvillea*. Officially speaking, the genus was first described by the French naturalist, Philibert Commerçon and named after the admiral and explorer, Louis Antoine de Bougainville who was the captain of the expedition that had brought Commerçon to Rio de Janeiro in 1766 during their circumnavigation of the world

But he was recovering from a leg injury and was officially confined to the ship while his leg healed. Then who was the brave, dedicated botanist doing most of the actual labour, carrying supplies and collecting specimens in a place as dangerous as Rio de Janeiro where the ship's chaplain was murdered ashore soon after their arrival?

The first woman to circumnavigate the world

It was Jeanne Baret, born a peasant women in Burgundy, who became an unwitting explorer and risked her life for the love of botany and, in doing so, became the first woman to circumnavigate the world. Since 18th century naval regulations in France prohibited women being on board a ship, Baret had to disguise herself as a man to join the expedition, and continued to wear men's clothes during the duration of the expedition.

Part I Women in Botany- Aritra Das, UG Semester VI

Baret was Commerson's assistant, but was also an accomplished botanist in her own right and evidence suggests that she was the one who made some of the expedition's most notable collections, including the showiest, most enduring botanical specimen from the expedition: *Bougainvillea* Comm. ex Juss.

They together collected over six thousand specimens, but while Commerçon was celebrated as a scientist, Jeanne Baret remained uncredited. During the expedition and the years after its successful completion, over seventy species would be named in honour of Commerçon using the specific epithet *commersonii*. Despite the important role she played, not a single species was named after her till 2012, when a newly discovered vine was named *Solanum baretiae,* more than two centuries after her death

And so we 'should' know Women in Science and Botany

This is certainly not the only case when women's contribution to the scientific community have been wilfully forgotten and due credit was denied to them while their work was attributed to their male colleagues. In fact, the bias against acknowledging the achievements of women scientists has been so strong over the course of our history, that this phenomenon has a name, the 'Matilda Effect'. This is precisely why we must encourage, celebrate, and most importantly remember the work of these extraordinary women in plant science:

Part I Women in Botany- Aritra Das, UG Semester VI

Edavalath Kakkat Janaki Ammal (1897-1984)

Early life

Ammal was born in Thalassery, Madras Presidency, British India (now in Kerala, India) to an aristocratic family on 4th November 1897. She obtained her honours degree in botany from Presidency College, Madras and subsequently was awarded the Barbour Scholarship to pursue her master's degree in the University of Michigan.

In an age when it was difficult for most women to make it past high school, she completed her PhD in Plant Cytology from the same institution, one of the USA's finest thus becoming the first Indian women to be awarded a doctorate in plant science.

Her works

She returned to India shortly after and joined the Sugarcane Breeding Station at Coimbatore. She was instrumental in the nobilization of wild canes in India by crossing hardy local species with high sugar yielding *Saccharum officinarum,* which made it withstand the harsh winters of North India. Janaki worked on several genera including *Solanum, Datura, Mentha, Cymbopogon* and *Dioscorea* and other medicinal and economically important plants. She attributed the higher rate of plant speciation in the cold and humid Eastern Himalayas as compared to the cold and dry Western Himalayas to polyploidy. Also, according to her, the confluence of Chinese and Malayan flora in the northeast of India led to hybridization events between these and the native flora of this region which further contributed to the greater diversity of plants.

Part I Women in Botany- Aritra Das, UG Semester VI

Janaki Ammal as an activist

After independence, our Prime Minister, Jawaharlal Nehru invited her to reorganize the BSI (Botanical Survey of India) and was appointed the first director of the Central Botanical Laboratory in Allahabad.

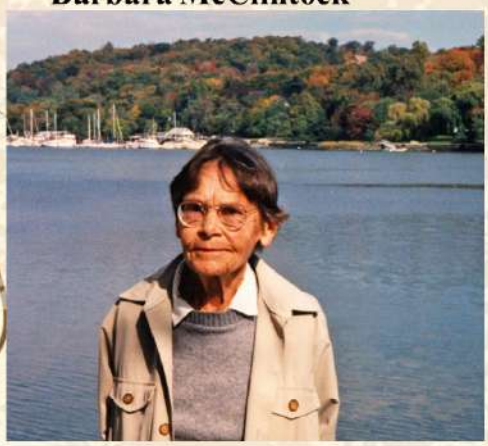
She took a keen interest in ethnobotany especially in the plants of medicinal and economic value from the rain forests of Kerala and was staunch advocate for the protection of biodiversity in the region and successfully saved the famous Silent Valley from being flooded by a hydroelectric project.The forest was subsequently declared a national park and is filled with rare varieties of orchids and due to Janaki's efforts, this park is now a popular tourist spot and its flora and fauna are flourishing. She was awarded Padma Shri in 1977 for her contributions to Indian agriculture and ecology.

Janaki Ammal as we remember her

Two awards were instituted by the Government of India, the 'E.K. Janaki Ammal National Award on Plant Taxonomy' and the 'E.K. Janaki Ammal National Award on Animal Taxonomy' to recognize the contributions of Indian taxonomists. She also has several taxa named in her honour, like *Sonerila janakiana*, a species of plant in the family Melastomataceae, and *Dravidogecko janakiae*, a species of geckos found in Kerala. Thus, E.K. Janaki Ammal emerges as one such hero, whose remarkable journey through life, beset by challenges was marked by a deep-rooted passion for botany, an unwavering commitment to preserving indigenous knowledge, and an indomitable spirit that reshaped India's botanical landscape.

Part I Women in Botany- Aritra Das, UG Semester VI

Barbara McClintock



Early life

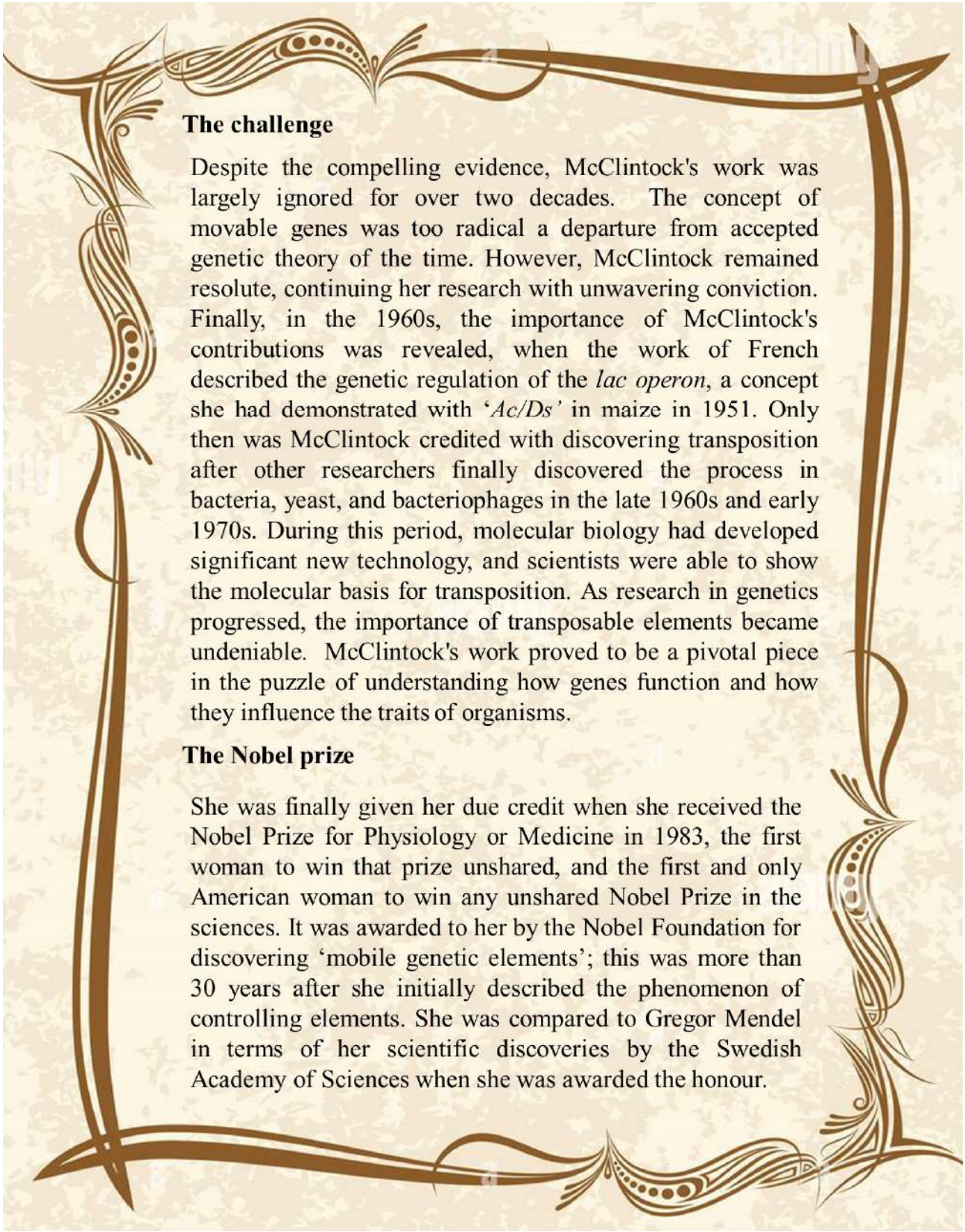
Barbara was born on the16th of June, 1902, in Hartford, Connecticut, USA. She began her studies at Cornell University's College of Agriculture in 1919 and studied botany, receiving her bachelor's degree in 1923.

Her interest in genetics began when she took her first course in that field in 1921 and went on to do her masters and doctorate from the same institution.

The 'odd woman out' discovers dancing sequences

During her graduate studies and postgraduate appointment as a botany instructor, McClintock was instrumental in assembling a research group that studied the new field of cytogenetics in maize that brought together plant breeders and cytologists including future Nobel laureate George Beadle, Marcus Rhoades, and Harriet Creighton. Some two decades before Watson and Crick described the structure of DNA, McClintock had observed that genes are physically located on the chromosomes, thus kickstarting the field of cytogenetics.McClintock's cytogenetic research was focused on developing ways to visualize and characterize chromosomes in maize kernels and developed a technique using carmine staining to visualize them showing for the first time the morphology of the ten maize chromosomes.Through meticulous research, McClintock revealed that genes could move or "jump," from one chromosome location to another. This phenomenon of 'jumping genes', later termed transposition, challenged the scientific community's understanding of a stable genome.

Part I Women in Botany- Aritra Das, UG Semester VI



The challenge

Despite the compelling evidence, McClintock's work was largely ignored for over two decades. The concept of movable genes was too radical a departure from accepted genetic theory of the time. However, McClintock remained resolute, continuing her research with unwavering conviction. Finally, in the 1960s, the importance of McClintock's contributions was revealed, when the work of French described the genetic regulation of the *lac operon*, a concept she had demonstrated with '*Ac/Ds*' in maize in 1951. Only then was McClintock credited with discovering transposition after other researchers finally discovered the process in bacteria, yeast, and bacteriophages in the late 1960s and early 1970s. During this period, molecular biology had developed significant new technology, and scientists were able to show the molecular basis for transposition. As research in genetics progressed, the importance of transposable elements became undeniable. McClintock's work proved to be a pivotal piece in the puzzle of understanding how genes function and how they influence the traits of organisms.

The Nobel prize

She was finally given her due credit when she received the Nobel Prize for Physiology or Medicine in 1983, the first woman to win that prize unshared, and the first and only American woman to win any unshared Nobel Prize in the sciences. It was awarded to her by the Nobel Foundation for discovering 'mobile genetic elements'; this was more than 30 years after she initially described the phenomenon of controlling elements. She was compared to Gregor Mendel in terms of her scientific discoveries by the Swedish Academy of Sciences when she was awarded the honour.

Part I Women in Botany- Aritra Das, UG Semester VI

Archana Sharma

Early life

Dr. Sharma was born on 16th February 1932 in Pune to a family of academicians. Her early education was in Bikaner, from where she obtained her Bachelor's degree. She then moved to Kolkata where she pursued MSc from the University of Calcutta.

She also completed her PhD and DSc from the same institution specializing in Cytogenetics, Human Genetics and Environmental Mutagenesis, therefore becoming only the second woman to have been awarded a DSc by the University.

Her role as the Indian cytogeneticist

Sharma started her professional career and became a Professor of Genetics in the Centre of the Advanced Studies in Cell and Chromosome Research. She was married to Prof. AK Sharma, the 'Father of Indian Cytology' and succeeded him as the Head of the Botany Department, University of Calcutta. Together, they developed novel methods of pre-treatment and staining cells to visualize chromosome structure. These techniques could be used for different plant cells and became very popular throughout the world. Based on their original work and the follow up investigations in their laboratory and others, Archana Sharma jointly with AK Sharma, published a book on chromosome techniques which soon became a standard reference book all over the world and the name 'Sharma and Sharma' became synonymous with plant chromosome research. One of important contributions that came from Archana's laboratory was on the new concept of speciation in vegetatively reproducing plants. This work was published, among other important journals, in *Nature*. She also studied the effect of plant products in modifying the cytotoxicity of known pollutants.

She had been a role model for many in the field of plant genetics and the scientific community at large. During her career, Professor Archana Sharma supervised about 70 PhD students, published over 400 research papers, and founded an international journal of cytology and allied topics, named *Nucleus*. This reflects on the commitment that she had towards plant science.

Part II Knowing plants of our platters

Beetroot: The Rebel with a Cause

Saswata Dey, (UG 2015- 2018), currently PhD Student, University of Cambridge

When you stroll through a garden, you're greeted by a stunning display of colours. Colours truly are an integral part of a plant's life. Flowers flaunt their petals all the time, fruits wear their vibrant coats, leaves showcase variegated patterns, and even roots sometimes join the colourful parade. Nature is an exhibition of art, with plants as the star artists. But what's the secret behind these dazzling hues? The answer lies in the fascinating interplay between light and special biochemical compounds called pigments. These pigments work like selective mirrors, absorbing some aspects of light and reflecting others. We all know that chlorophyll is the green man in the group. Carotenoids bring sunny yellows and oranges, while anthocyanins are mostly responsible for reds, blues, and magentas. These pigments either work solo or team up to create the beautiful colours we admire. Together, they make up a plant's very own colour palette.

The concept of plant colours, however, gets more intriguing as we delve deeper into the plant kingdom. Take a closer look at red pigments, and you'll find that the red of roses, *Hibiscus* L., or strawberries (the anthocyanins) isn't the same as the red of beetroots. Beetroot-red is a unique pigment called betalains that can only be found in the beetroot group and nowhere else in the plant kingdom. It's almost like a soap opera with plants- anthocyanins rule the colour scene, except for one rebellious group—the beetroots and their kin. This rebellion reminds us of the tale of Alexander the Great and the defiant Indian king Porus. Just as Porus stood his ground against Alexander's dominance, the beetroot defied the anthocyanin regime in the plant kingdom, creating its own colour palette and changing the colour rules forever.

The story of this colour clash goes back millions of years when a group of plants called Caryophyllales, including beetroot and its allies, decided to forge a new colour path with betalains. Betalains come from tyrosine, an essential protein component also important for various valuable compounds like opium in poppies ("Posto"), morphine, and even the psychedelic mescaline in cacti. Anthocyanin, on the other hand, is made from another protein component called phenylalanine. Scientists discovered a quirky trait in table beets- their tyrosine-producing enzyme works overtime, flooding the plant with tyrosine without many breaks. Normally, enzyme activity slows down when enough product is made, but not in this case. Beets saw this as their golden ticket to break free from the anthocyanins. They cleverly learned to utilize the excess tyrosine to make betalains, their special red colour. This strategy was also adopted by other group members like *Amaranthus* L. ('Notey Shaak' in bengali) *Bougainvillea* Comm. ex Juss. ('BaganBilas' in bengali), *Mirabilis* Riv. ex L. ('Sandhyamalati' in bengali), spinach, *Portulaca* L. ("Noneeya"), Quinoa ('Bethua shaak' in bengali) and cacti, all masters of the tyrosine enrichment trick.

But wait, there's more! These plants didn't just stop at making a unique colour. They also produced some unusual compounds. What kind of compounds, you ask? Well, how about dopamine, norepinephrine, and adrenaline? Sound familiar? These are the chemicals that influence our emotions and feelings, from happiness to nervousness, pleasure, excitement, and agitation ("adrenaline rush"). Popularly known as neurotransmitters, they usually hang out in our brains and nervous systems, guiding our moods and behaviours.

So, what are these human-type compounds doing in plants, especially in beetroots and their cousins? The answer is, we don't know for sure. Suddenly, humble beetroots aren't so humble anymore. They're powerhouses of both unique colour and animal-type neuro compounds. And here's the kicker- these neurotransmitters and beetroot colour are connected. It might sound like a sci-fi plot, but truth is stranger than fiction. These animal-type neurotransmitters have woven themselves into the chaos of colours in the plant kingdom. This unexpected combo of beetroot colour and neurotransmitters is like discovering a surprisingly delightful match, just like pineapple on pizza—a combination you didn't expect but might just love.

There's still a lot to uncover in this colourful saga, and that's exactly what we're exploring at the University of Cambridge with Prof. Samuel F. Brockington, alongside researchers around the globe. One thing is for sure: beetroots sparked a revolution in the colour code, and you'll never look at a beetroot the same way again.

If you're curious to learn more about beetroot's special colour, the neuro compound adventure in plants, or specialized tyrosine metabolism in Caryophyllales, get in touch with me at sd967@cam.ac.uk.

Untamed Grains: Exploring India's Wild Rice Species and Their Hidden Potential

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Keywords: Resistance, species, diversity

Oryza nivara
(Source: archive.gramene.org)

Oryza rufipogon
(Source: flowersofindia.net)

Oryza officinalis
(Source: biodiversity.bt/files)

Oryza minuta
(Source: forestryimages.org)

Oryza latifolia
(Source: inaturalist.org)

Rice, one of the three major staple food crops consumed by nearly half of the world populations. This crop belongs to the family Poaceae and comprises of two cultivated and 24 wild species. *Oryza sativa* L. is the major cultivated Asian rice with two distinct ecotypes 'indica' and 'japonica' and the other one is African *O. glaberrima* Steud. The former is domesticated in Asia and spread all over world while the latter remains confined to Africa. Our subcontinent is home to a number of wild rice species that play a crucial role in agricultural biodiversity, genetic research, and local ecosystems. This article explores different wild rice species found in India, highlighting their chromosome numbers, states of cultivation, and individual uses.

Wild Rice Species in India

1. *Oryza nivara* S.D. Sharma & Shastry (2n=2x=24, AA genome):

- State of Cultivation: In states of Uttar Pradesh, Madhya Pradesh and Chattisgarh

- Uses: *O. nivara* is a wild progenitor of the Asian cultivated rice. It is highly valued in genetic research for its resistance to diseases and pests, particularly brown planthopper and bacterial blight.

2. *Oryza rufipogon* Griff. (2n=2x=24, AA genome)

- State of Cultivation: In states of West Bengal, Assam, and Odisha.
- Uses: Known as the common wild rice, it is an ancestor of *Oryza sativa*. It is a vital genetic resource for improving yield and stress tolerance in cultivated rice. It's long awns and red grains also make it a subject of study for understanding domestication purposes.

3. *Oryza officinalis* Wall. ex Watt (2n=2x=24, CC genome)

- State of Cultivation: Found in wetlands of Kerala, Karnataka and Tamil Nadu
- Uses: *O. officinalis* possesses genes for drought tolerance and disease resistance, which are crucial for developing resilient rice varieties.

4. *Oryza minuta* J.Presl (2n=4x=48, BBCC genome)

- States of Cultivation: In states of Assam, Manipur, Nagaland and some parts of Kerala
- Uses: This wild species possesses traits that confer tolerance to various abiotic stresses such as drought, salinity, and low soil fertility. It also contains genes that provide resistance to several pests and diseases, including bacterial blight and stem borers.

5. *Oryza latifolia* Desv. (2n=4x=48, CCDD genome)

- States of Cultivation: In states of Odisha
- Uses: It is a vital resource for genetic research due to its polyploid nature and unique genetic makeup. Also possess genetic traits that contribute to tolerance against drought and various other abiotic factors. It is also resistant to several pests.
- Protecting and conserving wild rice species is essential for the future of rice cultivation. The genetic diversity found in wild rice will be critical for developing resilient rice varieties as climate changes continues to poses new challenge to agriculture. In conclusion, the wild species of rice in India are not just botanical curiosities; they are the key to the future of sustainable rice cultivation. By harnessing the hidden potential of these untamed grains, we can enhance the resilience and productivity of cultivated rice, ensuring the future generation has the food security to look forward to.

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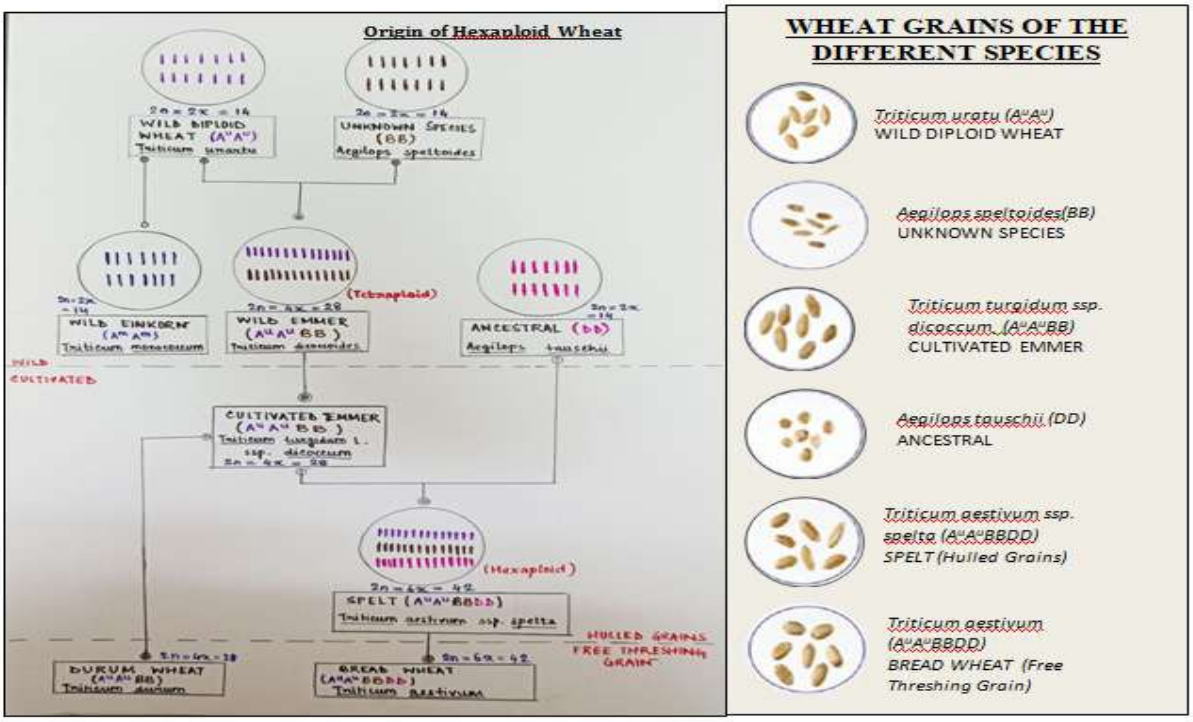
WHEAT: Origin, Types and the Culinary Uses

Aparajita Sengupta, UG Semester IV

Keywords: Origin of wheat, Types of wheat



Wheat (*Triticum aestivum* L.) is one of the fundamental food crops of the Poaceae family, cultivated all over the world. In India, wheat serves as a staple food and is grown widely in the Northern parts of the country- covering Punjab, Haryana, Western Uttar Pradesh and some areas of Madhya Pradesh. Wheat has wide culinary uses and provides us with carbohydrate (starch), protein (gluten), minerals (Cu, Mg, Zn, P and Fe), Vitamin B and E group, and dietary fibres.

ORIGIN OF WHEAT:

According to N.I. Vavilov and his colleagues, all the 14 recognized species of wheat can be genetically classified into 3 categories- *Diploid (x=7), Tetraploid (x=14) and Hexaploid (x=21)*; where x denotes the number of chromosomes in their sex cells. It was believed that the Tetraploid and Hexaploid forms of wheat originated from the ancient diploid wheat and related wild grass species by natural hybridization and chromosome doubling. Four different genomes – A, B, D and G were recognized (each representing a set of 7 chromosomes each).

There are more than 25,000 varieties of *Triticum aestivum* adapted to different temperate environments. Based on the growing seasons, wheat is classified into- spring wheat and winter wheat. The former sown in the month of March-May and harvested during August-September, while the latter has a longer growing season and is sown during October-November and harvested during May-July. About 80% of world's wheat is winter wheat. With respect to the chemical compositions of wheat, it can be of the Hard and the Soft type.

Soft Wheat	**Hard Wheat**
Pale in colour	Dark and Vitreous
Lower percentage of Gluten Hence regarded as *'weak' flour*	*Gluten content is high* Hence regarded as *'strong' flour*
Lacks ability to form strong dough and thus used to prepare cookies, pastries, and household flour.	Suitable for strong dough like bread where the development of a strong gluten network is desired

According to 'Official Grain Standards' in the United States, the different types of wheat are:

a) Hard Red Spring wheat b) Hard Red Winter wheat c) Soft Red Winter wheat

d) Soft White Spring wheat e) White wheat f) Durum wheat

The approximate protein content of wheat ranges from 9-18%. As compared to the ancient wheat, modern wheat has lower percentage of protein as the larger and heavier grain of modern wheat with a larger starchy endosperm lowers the protein content. However, Durum wheat provides with the maximum amount of protein than any other cereals and is used in the preparation of pasta and macaroni. Semolina is made from durum wheat that is milled coarse. The common wheat, used in the production of cakes and biscuits have around 7-11% protein, while that intended for the preparation of bread requires 12% or more amount of protein content. The Hard Red Winter wheat is the most versatile form with excellent milling and baking properties and is used as the general purpose flour. The Hard Red Spring wheat on the other hand is used for breads, rolls, croissants and is a valued improver in flour blends. Soft wheat with less protein content are used in the preparation of cookies, pretzels, biscuits, cakes and Asian noodles. The Hard White wheat, cultivated much less in comparison to the other types, receives enthusiastic reviews when used for Asian noodles, whole wheat, pan breads and flat breads.

Apart from the culinary uses, wheat is used in the manufacture of starch, gluten, distilled spirits, malt, etc. Wheat starch is preferred by many laundries for use in finishing cloth. Gluten is used to produce Monosodium glutamate (MSG) that adds flavour to food.

Nowadays, a number of researches are going on and the production of hybrid wheat is considered to be a major breakthrough as it gives a much increased yield. In India, it will not be that long before farmers sow hybrid wheat in their fields.

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The Mystery of the Purple Spots in Maize

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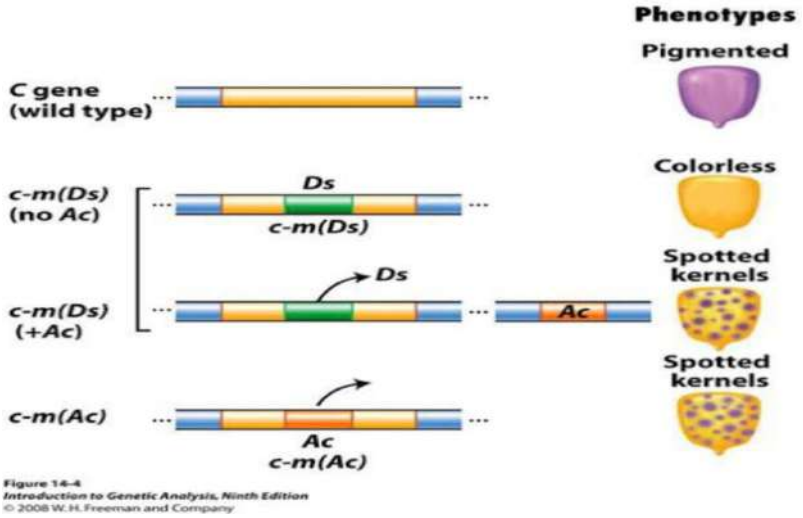
Maize (*Zea mays* L.) is the world's leading crop and is widely cultivated as cereal grain that was domesticated in Central America. Globally, maize is known as queen of cereals because of its highest genetic yield potential. Maize is the third most important cereal crop in India after rice and wheat. Maize have many types like normal yellow/ white grain, sweet corn, baby corn, popcorn, waxy corn, high amylase corn, high oil corn, quality protein maize, etc. Maize (*Zea mays* L.) belongs to the family Poaceae. The number of chromosomes in *Zea mays* is 2n= 20.

The discovery of gene sequences in chromosome, causing genetic instability is a very important process in genetics. Transposable elements are very important components in eukaryotic genome, they have ability to change their position within a genome. These components are known as transposable elements or jumping genes, which were first identified in maize by Barbara McClintock. She discovered the Ac and Ds elements by studying chromosome breakage in maize. McClintock won the Noble Prize for her introduction of the concept of transposons.

Barbara McClintock was an American geneticist, cytologist and botanist. She had to face immense discrimination during those days as female student were rare and are not socially accepted in the field of science. Thus she had to change her institution frequently. Her main area of study was genetics in corn pigment colouration due to presence of C gene which causes formation of red pigment anthocyanin giving purple colouration to the kernels. Her main area of interest being presence of purple spots in the colourless kernels, it was thought that such deviation was not due to conventional mutation but rather for some mobile genetic material . She hypothesized the presence of certain Ac and Ds elements responsible for this. The gene C with allele C and c producing purple or colourless condition in the aleurone layer of maize grains, insertional mutation of C gene causes its suppression leading to production of colourless condition. Ac also known as activator element (a sequence with 4563 repeats and terminal IRs) is

responsible for production of transposase and other enzyme which can remove and attach itself and also Ds elements (similar to Ac sequence except the presence of certain genes encoding enzymes required for transposition, hence a bit shorter in length) resulting its excision and attachment to another site. The breakage of chromosome occurs at p arm of chromosome 9.The combination of these genes along with when one or more of these genes are removed by the activity of Ds elements results in the colour variegation in corn kernel.



Gene			Functions
C	alleles	C	dominant form causes purple colour to the kernel
		c	
I	alleles	I	Dominant form is inhibitory to C gene (dominant epistatsis)
		i	
Bz	alleles	Bz	Bronze aleurone if bz is present
		bz	

Conclusion: Through these experiments, McClintock recognized that breakage occurred at specific sites on maize chromosomes. Barbara McClintock is rightly viewed as one of the pioneering figures in modern genetics.

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Rare Mushroom Wonders: Culinary, Nutritional and Economic Discoveries

Smritam Maity, Research Scholar

In the hidden corners of forests, amidst the fallen leaves and decaying wood, thrive some of nature's most intriguing organisms: Mushrooms are found in different forms but in this passage, only the rare mushrooms are distinguished. These peculiar and quite mysterious organisms, which go unnoticed and are unknown by many, carry with them a lot of surprises and truths that are beyond any importance. Rare mushrooms are underappreciated despite their distinct flavour that complements gourmet cuisine and their health benefits that encourage consuming nutrient-dense foods. Furthermore, they pose economic benefits that are captivating young businessmen and researchers, thus revealing potential in sustainable agriculture and small specialty markets. This investigation into the exotic fantastic and peculiar fungi reveals them to be not only gourmet treasures, source of nutrients, vitamins and purported cure-all, but also a new income-generating gold mine which the world has barely scratched at this stage.

Mushrooms, amazing organisms of the fungal domain, have been used since time immemorial primarily for their characteristic flavour and taste in meals as well as possible nutritional and even therapeutic value. There are two main types of mushrooms widely used; both are button and portobello mushrooms, but there are a variety of other edible mushrooms that differ not just in their biochemical makeup but also in the potential medical uses they may have. In this segment of the scientific analysis, much focus is accorded to seven strange looking edible mushrooms describing their chemical composition and physiological impact, as well as their potential value for the economy.

1. Lion's Mane [*Hericium erinaceus (Bull.) Pers.*]

Biochemical Constituents:

- **Hericenones and Erinacines**: Bioactive compounds unique to Lion's Mane mushrooms, known for their neuroregenerative properties by stimulating nerve growth factor (NGF) production.
- **Beta-glucans**: Polysaccharides with immune-enhancing effects, supporting overall immune function and potentially aiding in cancer prevention.

Physiological Effects:

- **Neuroprotection**: Lion's Mane mushrooms have shown promising results in preclinical studies for enhancing cognitive function and promoting nerve regeneration, offering

potential therapeutic applications for neurodegenerative diseases like Alzheimer's and Parkinson's.

- **Immune Modulation**: The presence of beta-glucans may stimulate immune responses, enhancing the body's defense mechanisms against infections and diseases.

Economic Implications:

- Cultivation of Lion's Mane mushrooms can be relatively straightforward, requiring substrates such as hardwood sawdust or straw.
- The high market demand for Lion's Mane mushrooms, driven by their unique taste and potential health benefits, presents lucrative opportunities for commercial cultivation and distribution.

(Diagram-Lion's mane Mushroom)

2. Maitake [*Grifola frondosa* (Dicks.) Gray.]

Biochemical Constituents:

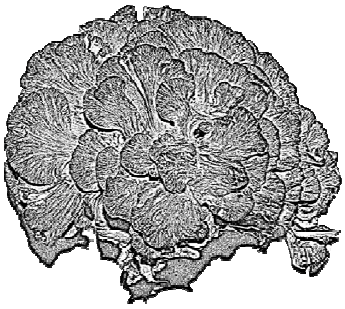
- **Beta-glucans**: Abundant polysaccharides in Maitake mushrooms, known for their immunomodulatory effects and potential anticancer properties.
- **D-Fraction**: A specific polysaccharide isolated from Maitake mushrooms, studied for its ability to enhance immune function and inhibit tumor growth.

Physiological Effects:

- **Immune Enhancement**: Maitake mushrooms have been shown to stimulate immune cell activity and enhance the body's defense against infections and cancer.
- **Blood Sugar Regulation**: Some studies suggest that Maitake mushrooms may help regulate blood sugar levels, making them potentially beneficial for individuals with diabetes.

Economic Implications:

- Maitake mushrooms can be cultivated on various substrates, including hardwood logs and sawdust blocks, offering versatility in cultivation methods.
- Their potential health benefits and culinary appeal contribute to their high market demand, making them a profitable crop for commercial growers.



(Diagram-Maitake Mushroom)

3. Chicken of the Woods [*Laetiporus sulphureus* (Bull.) Murrill. *]*

Biochemical Constituents:

- **Laetiporic Acid**: An antimicrobial compound found in Chicken of the Woods mushrooms, potentially contributing to their defense against pathogens.
- **Protein**: Chicken of the Woods mushrooms are relatively rich in protein, providing a valuable nutrient source for vegetarians and vegans.

Physiological Effects:

- **Antimicrobial Activity**: The presence of laetiporic acid may confer antimicrobial properties to Chicken of the Woods mushrooms, potentially aiding in the prevention of infections.
- **Dietary Protein**: The protein content of Chicken of the Woods mushrooms makes them a nutritious meat substitute, supporting muscle growth and repair.

Economic Implications:

- Cultivation of Chicken of the Woods mushrooms can be facilitated by utilizing decaying hardwood as a substrate, contributing to sustainable forestry practices.
- Their unique texture and flavour, coupled with their potential health benefits, contribute to their market demand and economic viability for commercial cultivation.

(Diagram-Chicken of the Woods Mushroom)

4. Black Trumpet [*Craterellus cornucopioides* (L.) Pers.]

Biochemical Constituents:

- **Polyphenols**: Black Trumpet mushrooms contain various polyphenolic compounds, known for their antioxidant properties and potential health benefits.
- **Minerals**: Rich in essential minerals such as potassium and zinc, contributing to overall health and well-being.

Physiological Effects:

- **Antioxidant Activity**: The polyphenols present in Black Trumpet mushrooms help scavenge free radicals and reduce oxidative stress, protecting cells from damage.
- **Nutrient Density**: The mineral content of Black Trumpet mushrooms supports various bodily functions, including immune health and metabolic processes.

Economic Implications:

- Cultivation of Black Trumpet mushrooms can be challenging due to their symbiotic relationship with certain tree species, but their rarity and unique flavor contribute to their high market value.
- Despite their limited availability, Black Trumpet mushrooms represent a niche market opportunity for gourmet chefs and specialty food retailers.

(Diagram-Black Trumpet Mushroom)

5. Enoki [*Flammulina velutipes* (Curtis) P. Karst.]

Biochemical Constituents:

- **Ergothioneine**: Enoki mushrooms contain ergothioneine, a unique antioxidant with potential health-promoting properties.
- **Vitamins**: Rich in vitamin-B complex such as niacin, riboflavin and pantothenic acid, essential for energy metabolism and overall health.

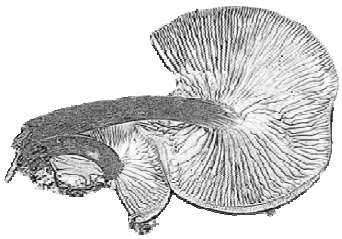
Physiological Effects:

- **Antioxidant Protection**: Ergothioneine in Enoki mushrooms helps protect cells from oxidative damage and may contribute to longevity and disease prevention.

- **Vitamin Support**: The vitamin-B complex present in Enoki mushrooms play vital roles in cellular function, nerve health and energy production.

Economic Implications:

- Enoki mushrooms are well-suited for controlled cultivation environments, offering rapid growth and high yields.
- Their popularity in Asian cuisine and increasing recognition in global markets contribute to their economic viability and potential for commercial cultivation.



(Diagram-Enoki Mushroom)

6. Beech Mushrooms [*Hypsizygus tessellatus* (Bull.) Singer.]

Biochemical Constituents:

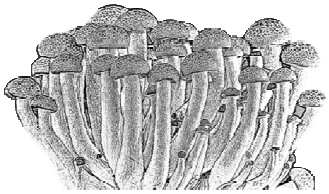
- **Ergothioneine**: Similar to Enoki mushrooms, Beech mushrooms contain ergothioneine, a potent antioxidant associated with various health benefits.
- **Protein**: Beech mushrooms are a good source of dietary protein, essential for muscle growth and repair.

Physiological Effects:

- **Antioxidant Defense**: Ergothioneine in Beech mushrooms helps neutralize free radicals and reduce inflammation, supporting overall health and well-being.
- **Protein Provision**: The protein content of Beech mushrooms makes them a valuable addition to vegetarian and vegan diets, supporting protein needs without animal products.

Economic Implications:

- Beech mushrooms can be cultivated on various substrates, including agricultural waste products, offering sustainable cultivation options.
- Their versatility in culinary applications and potential health benefits contribute to their market demand and economic viability for commercial growers.



(Diagram-Beech Mushroom)

7. Shimeji [*Hypsizygus marmoreus* (Peck) H.E. Bigelow.]

Biochemical Constituents:

- **Vitamins and Minerals**: Shimeji mushrooms are rich in vitamin-B complex, potassium and zinc, supporting overall health and vitality.
- **Dietary Fiber**: High in dietary fibre promoting digestive health and regular bowel movements.

Physiological Effects:

- **Nutrient Support**: The vitamins and minerals in Shimeji mushrooms play essential roles in energy metabolism, immune function and cellular health.
- **Digestive Health**: The dietary fiber content of Shimeji mushrooms supports gastrointestinal health, aiding in digestion and nutrient absorption.

Economic Implications:

- Shimeji mushrooms are well-suited for commercial cultivation due to their adaptability to various substrates and controlled environments.
- Their popularity in Asian cuisine, coupled with their nutritional richness, contributes to their market demand and economic viability for commercial production.

(Diagram-Shimeji Mushroom)

Uncommon edible mushrooms offer a fascinating glimpse into the intricate world of fungi, presenting not only diverse flavours and textures but also a treasure trove of biochemical constituents with potential health benefits. In summary, Lion's Mane is a highly potent mushroom that strengthens the neurons in the brain while Chicken of the Woods possesses antimicrobial qualities complimenting its enticing taste. Each mushroom harbours unique compounds that contribute to its culinary appeal and physiological effects. Conversely, the growth of these mushrooms offers economic utils, such as sustainable forest management for the Chicken of woods to controlled growth environments for Enoki and Shimeji mushrooms. As our understanding of mushrooms continues to deepen, there is a growing appreciation for their culinary, nutritional and economic significance. Appreciating a diverse and often overlooked variety of edible mushrooms is not only healthy and delicious additions to our diets,

but they can also enrich the downstream agricultural practices that enable their growth. We however must now embark on a voyage of discovery of the wonders of nature that exist in such simple yet complex organisms.

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-Somrita Sinha, PG Sem III

Do plants have a nervous system?

Somrita Sinha, PG Sem – III

For centuries, plants have been relegated to the realm of passive bystanders in the natural world. They lack the obvious signs of complex life – no brains, no nervous system, and seemingly slow reactions. However, recent research is challenging this view, revealing a hidden world of plant communication that pushes the boundaries of our understanding.

Traditionally, animals have been the sole proprietors of nervous systems. These intricate networks of specialized cells, neurons, allow for rapid transmission of electrical signals, enabling animals to react swiftly to their environment. Plants, on the other hand, rely on slower chemical messengers called hormones to coordinate their activities. Plants use a complex network of chemical messengers, like auxins and cytokinin, to coordinate growth, development, and response to the environment act as the neurotransmitter. These hormones act much like slow-moving messages, carrying information throughout the plant.

But here's the twist: Plants exhibit electrical signaling too! Studies have shown that when a leaf is damaged, it triggers an electrical wave that travels throughout the plant. This wave, remarkably like an animal nerve impulse, uses calcium ions instead of sodium ions, but achieves a similar goal – sending a message.

Electrical Whispers: Plants generate electrical signals like animal neurons, albeit weaker. Studies like PLANTELEXIGNAL are pinpointing the molecules responsible for these signals, hinting at a complex electrical language within the plant [CORDIS: 'Nervous System' of plants revealed].

Furthermore, plants appear to use these electrical signals for communication. Research suggests that a wounded leaf can not only alert its own tissues, but also warn neighbouring plants. When attacked by caterpillars, for example, some plants release volatile chemicals that not only repel the herbivores but also signal to nearby plants of the impending danger. These neighboring plants then ramp up their defenses in anticipation of an attack.

This research has sparked debate. Some scientists argue that these findings justify the term "plant nervous system," highlighting the sophisticated communication networks within plants. Others argue that

the term is misleading, as plant communication lacks the complexity and speed of animal nervous systems. Regardless of the terminology, the new research paints a far more dynamic picture of plant life. Plants are no longer passive observers, but actively sense and respond to their environment. They communicate with each other, warn each other of danger, and even exhibit a form of memory.

This newfound understanding of plant communication has significant implications. It could lead to new methods of pest control, by disrupting plant signaling pathways. It could also help us develop more stress-resistant crops, by understanding how plants communicate their needs.

The story of plant communication is far from over. As research continues, we may discover even more sophisticated ways in which plants interact with their world. Perhaps the "untold story" of plants is not just about a nervous system, but about a whole new way of understanding the intelligence and resilience of the plant kingdom.

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Unleashing the Power of Virus-Induced Gene Silencing (VIGS) in Crop Improvement and its Epigenetic Advancements

Somrita Sinha, PG Sem – III

In the realm of agricultural innovation, the emergence of Virus-Induced Gene Silencing (VIGS) has proven to be a revolutionary tool, offering unprecedented possibilities for crop improvement. This sophisticated technique utilizes viral vectors to selectively silence target genes, providing researchers with a powerful means to decipher gene functions and enhance desired traits in crops.

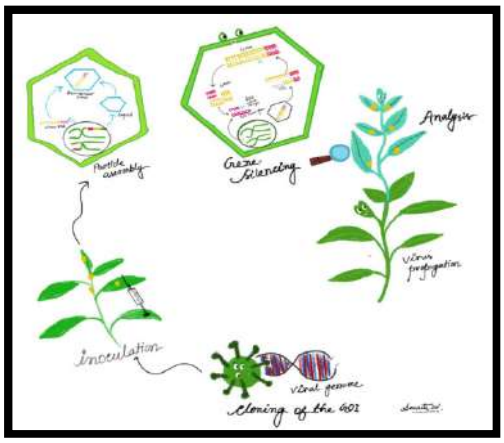
At its core, VIGS operates through the introduction of a viral construct that carries a fragment of the target gene. Once infiltrated into the plant host, the viral vector triggers RNA silencing, leading to the suppression of the corresponding gene's expression. This precise modulation allows scientists to investigate the impact of specific genes on plant development, stress resistance, and overall performance.

One of the key advantages of VIGS lies in its versatility. Unlike traditional genetic modification methods, VIGS is transient, allowing for the temporary suppression of genes without permanently altering the plant's genome. This temporary nature is particularly advantageous for rapid screening of gene functions and can significantly expedite the breeding process. Crop improvement has been a central focus of VIGS applications. By selectively silencing genes associated with undesirable traits or enhancing those related to desired characteristics, researchers can expedite the development of crops with improved yield, resilience to environmental stressors, and nutritional content. The precision offered by VIGS ensures a targeted approach, minimizing unintended consequences and accelerating the pace of crop enhancement.

Furthermore, VIGS has made substantial strides in the field of epigenetics. Epigenetic modifications play a key role in regulation of gene expression without altering the underlying DNA sequence. VIGS has been instrumental in uncovering the intricate interplay between epigenetic mechanisms and plant development. By selectively silencing genes involved in epigenetic regulation, researchers gain insights into the epigenetic landscape of plants, paving the way for innovative strategies to manipulate these mechanisms for crop improvement. Epigenetic modifications, such as DNA methylation and histone acetylation, influence various aspects of plant physiology, including stress response, flowering time, and nutrient uptake. VIGS has been employed to investigate the specific genes involved in these processes, shedding light on the epigenetic factors that can be targeted for crop optimization.

In recent years, VIGS has evolved beyond conventional gene silencing to offer a nuanced understanding of how epigenetic modifications influence crop traits. Researchers are now leveraging VIGS to unravel the intricacies of small RNA-mediated silencing pathways and their impact on epigenetic regulation. This advancement opens new avenues for harnessing epigenetic modifications as a tool for crop improvement, allowing for precise control over traits without resorting to permanent genetic alterations.

In conclusion, Virus-Induced Gene Silencing stands as a powerful ally in the pursuit of crop improvement. Its ability to selectively silence genes, coupled with advancements in unraveling epigenetic complexities, propels agricultural innovation to new heights. As we unlock the potential of VIGS, the dream of tailoring crops to meet the demands of the future becomes not just a possibility but a promising reality. The journey from understanding gene functions to manipulating epigenetic landscapes through VIGS marks a pivotal chapter in the ongoing narrative of scientific progress in agriculture.



Virus-Induced Gene Silencing (VIGS) in Crop Improvement

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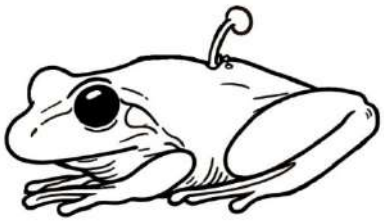
Fungus, Among us? A curious case of Frog - Fungal interaction in the Western Ghats

Agnik Bhattacharya, Semester IV, agnikbhattacharya04@gmail.com



In June 2023, while trekking amidst the verdant foothills of the Kudremukha range in the Western Ghats of Karnataka, Chinmay C. Maliye and Lohit Y.T. found a group of frogs in a rainwater fed pond by the side of the road. They soon realized it was an army of Rao's intermediate golden-backed frogs (Hylarana intermedia). It was not something out of the ordinary as these amphibians are found in relative abundance in the lush, wet tropical forests of the Ghats. But on closer inspection, they observed that one individual had a distinct white outgrowth from its shiny green and golden skin. What they observed wasn't a typical rainforest discovery – the frog was sporting an unexpected accessory: a mushroom sprouting from its side. This chance encounter made headlines as this bizarre phenomenon sparked a wave of scientific curiosity, particularly regarding the enigmatic fungus and the ecological context that led to this unique situation.

The mushroom in question was tentatively identified as belonging to the Mycena genus. Mycenae are a diverse group of saprotrophic fungi, and thus decompose dead or decaying organic matter. They are known for their slender stature, delicate gills, and preference for moist environments – all characteristics that align with the observed specimen. However, the exact Mycena species remains a mystery. Positive identification typically requires detailed examination of the gills, spore colour, and even genetic analysis. But the mere presence of a macrofungus on a live amphibian is highly unusual. Fungi typically establish themselves on dead or decaying plant matter, where they can readily access nutrients for growth and reproduction. So, how did this end up on a living frog?

The Kudremukha range is located at the tri-junction of Dakshina Kannada, Udupi and Chikmagalur districts of Karnataka and isa biodiversity hotspot, boasting a rich tapestry of flora and fauna. The Kudremukha National Park is a part of the world's 38 ‘hottest hotspots’ of biological diversity and is a UNESCO World Heritage Site. The Western Ghats, of which Kudremukha is a part, are known for their amphibian endemism, with *Hylarana intermedia* being one such example. Humidity and frequent rainfall, create an ideal environment for fungi like Mycena to thrive. These moist conditions also favour amphibians like Rao's intermediate golden-backed frog, as they facilitate water absorption through their permeable skin. Thus, the very conditions that support the frog population might also inadvertently create opportunities for fungal encounters.

The Western Ghats form a biosphere which contains 1,273 endemic plant and over 340 endemic animal species. The intricate web of interactions between the flora, fauna and the microbes are the reason why it is a biodiversity hotspot where both the frog and the fungus have an equal role in maintaining the delicate trophic balance which exists in the region. Thus, understanding the interactions of the amphibians with fungal species in the environment can reveal why certain amphibians are susceptible to the fungal infections, and why some succumb to its fatal effects which others are able to coexist with the fungus, as is the case of the Frankenstein formed of *Mycena* and *Hylarana intermedia*. This understanding will prove crucial for protecting the fragile ecosystems which are rapidly degrading due to direct and indirect human intervention. In the meanwhile all we can do is wonder what other fungus is ‘among us’.

While *Mycena* have been known to colonize living plant roots, any interaction with living animal tissue was unheard of. And the “bonnet” arising out of the skin was merely the fruiting body of the fungus, thus, there must have been significant mycelial penetration inside the skin of the amphibian. Yet, the frog appeared healthy by all matrices and seemed to retain normal locomotory and sensory functions. It was known that amphibian skin is a complex ecosystem teeming with microbial life, including bacteria, fungi, and even algae and this diverse microbial community plays a crucial role in amphibian health and it is possible that this specific fungus, while not typically a resident, found a niche within the microbiome on the frog's skin. But what could not be understood was the exact nature of this weird interaction. Was it commensalism? A harmless hitchhiker using the frog as a means of dispersal? Was it parasitism? A simple case of an opportunistic fungus calling first dibs on a future meal? Or was it a symbiotic relationship where the frog was also deriving some benefit? Alas, the specimen was not collected and therefore neither the exact species of the Mycena mushroom which is crucial for understanding its ecological preferences nor its potential impact on the frog could be studied. Therefore, this discovery has raised more questions than it has answered. This might be an isolated incident, or it could represent a more widespread phenomenon signaling the increased vulnerability of amphibian species towards fungal diseases.

The discovery of the dreaded chytrid fungus *Batrachochytrium dendrobatidis* (Bd) in frogs in the Western Ghats, which causes the infectious and fatal skin disease chytridiomycosis and is notorious for causing frog declines and extinctions worldwide, have got Indian scientists worried as it has been detected in all major biodiversity hotspots in India from the Western Ghats, Eastern Ghats, Eastern Himalayas to the Andaman and Nicobar Islands. A 2019 review in the journal Science assessed that chytridiomycosis was a factor in the decline of at least 501 amphibian species during the past 50 years, of which 90 species were confirmed or presumed to have gone extinct in the wild and another 124 had declined in numbers by more than 90% and thus was termed as the "greatest recorded loss of biodiversity attributable to a single disease". Rising temperatures and unpredictable weather patterns due to climate change are just accelerating this process.

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Arsenic in DNA Backbone: A Bacterium's Potential for Redefining Life's Elements

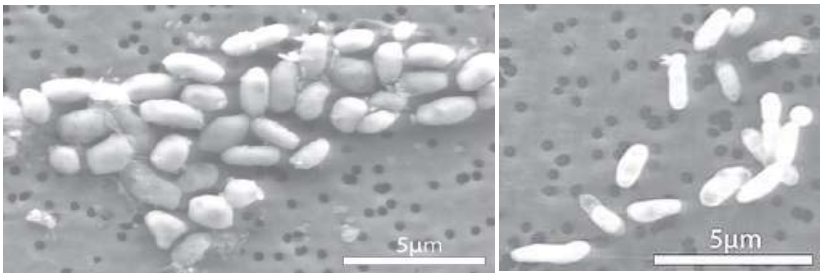
Parikh Guha Ray, UG-Semester IV

As we know, most of the biomolecules in a living cell are made up of primarily six major elements, which are carbon (C), hydrogen (H), nitrogen (N), oxygen (O), sulfur (S), and phosphorus (P). Out of these elements, phosphorus is a major macromolecule, which is also a major component of nucleic acids (constituting its sugar phosphate backbone) and cell membranes (constituting phosphoglycerids mainly). Here we will look into a bacterial strain discovered from Mono Lake in the state of California, USA, by F. W. Wolfe-Simon et al. (2011) that have the capability to switch its phosphate to arsenate in the backbone of its nucleic acid in the presence of arsenic (As) in its surroundings.

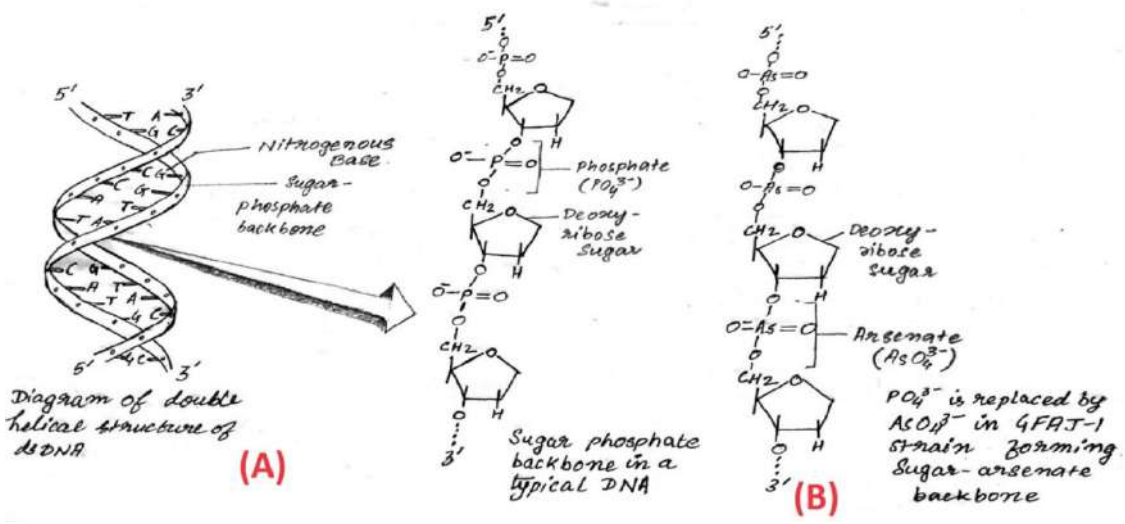
Mono Lake in California is a hyper saline alkali lake with a high concentration of dissolved arsenic. From the sediments of these lakes, an inoculum was cultured in an artificial medium (pH 9.8) by researchers. They then transferred it to a nutrient agar plate, where they reduced the phosphorus content and introduced arsenic, which then showed 20-fold growth in six days. The strain was identified from 16S rRNA analysis as GFAJ-1, belonging to the family Halomonadaceae of Gammaproteobacteria. Members of this family are known to accumulate intracellular As. To check whether or not it is uptaking the As from the surroundings, they used radiolabeled $^{73}AsO_4^{3-}$, and it showed a positive result for the uptake of As from its medium; however, its mechanism for the uptake of As is still not known. From ICP-MS (inductively coupled plasma mass spectroscopy) of cells from +P/-As culture and also cells from +As/-P culture of their genome, resulting in similar fractions of P and As, respectively. A major part of this $^{73}AsO_4^{3-}$ was also incorporated into its intracellular proteins. These results were well in accordance with other similar experiments like cell fraction analysis, x-ray analysis, etc. Small molecular weight metabolites may also potentially include arsenylated analogues in ATP, acetyl coA, etc. Finally, X-ray data confirms the position of As in a similar configuration to P in the DNA backbone and potentially in other biomolecules as well. This observation is supported by

the fact that P and As have similar properties in terms of ionic radii and electronegativity, as both of them are present in the same group 15 in the modern periodic table, but they differ later in biological pathways in terms of their reactivity. Therefore, this bacterium shows an interesting deviation from our standard biochemistry of nucleic acid due to the replacement of $^{73}AsO_4^{3-}$ with standard PO_4^{3-} in the DNA backbone.

Critics: Although this was a bold claim, this theory was highly criticized by scientists, and NASA's statement on the paper saying that this would impact the search for evidence of extraterrestrial life was also highly disregarded. The main or pioneering scientist against this claim was M.L. Reaves and Rosemary Redfeild from the University of California, where they did CsCl centrifugation along with liquid chromatography mass spectrometry and found trace evidence of As. The original researcher stated that CsCl centrifugation is not the best method for GFAJ-1 DNA analysis as As-containing DNA is extremely fragile. Another very possible drawback of Redfield's experiment is that she was not completely able to remove P from the +As/-P medium-growing GFAJ-1 strain. Other scientists have also concluded that Redfeild and her colleague have found many definitive refutations against the claims, but we cannot disregard the complete absence of As in the DNA of the GFAJ-1 strain. Thus, the debate is still on, and it leaves us with the question: will there be any day after thousands or millions of years when phosphate in the DNA backbone will be completely replaced by arsenate??



Scanning electron micrography of strain GFAJ-1 under condition +As/-P and -As/+P respectively. Showing cells having arsenate in medium having higher volume (source: A bacterium that can grow using arsenic instead of phosphorus by Wolfe-Simon et al 2011.



A hand drawn diagram depicting – (A) Position of phosphate (PO_4^{3-})in DNA backbone , (B) replacement of P by As in DNA backbone.

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Aquatic Plants for Aquarium: Generating Economic Importances

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Keywords: Aquatic plants, Aquarium, Economic importance

Aquatic plants play a crucial role in offering a range of benefits, from enhancing the aesthetic appeal of aquariums to contributing to ecosystem balance and even providing income opportunities. Aquatic plants serve as natural filters, absorbing excess nutrients like Nitrates (NO_3^-) and Phosphates (PO_4^{3-}) which helps maintain water quality and prevent bio-fouling means. This natural filtration reduces the need for chemical additives, saving money for aquarium owners and reducing the environmental impact of aquarium maintenance. Moreover, the aesthetic appeal of well-maintained aquatic plants can significantly increase the value of aquariums. Hobbyists often invest in rare or exotic species, driving demand in niche markets. This demand has led to the emergence of specialized nurseries, shops and online stores dedicated to cultivating and selling unique aquatic plants. Additionally, aquatic plants provide habitat and food for ornamental fish, supporting biodiversity within aquarium ecosystem. Many aquatic plants like *Cabomba caroliniana* A.Gray, *Bacopa monnieri* (L.) Wettst., *Vallisneria* P.Micheli ex L., *Cryptocoryne* Fisch. ex Wydler, *Hydrilla* Rich., *Nymphaea* L. have a great economic importance in ornamental fish market for aquarium. These plants can be farmed or it can be directly sold to market. Large-scale fish farms utilize aquatic plants to improve water quality and provide natural forage for their stock fishes. In landscaping, aquatic plants are used in ponds, lakes, and water features to promote ecological balance. Furthermore, the trade of aquatic plants has created employment opportunities in cultivation, distribution, and maintenance. In regions with favourable climates, aquaculture farms employ workers to propagate, harvest, and ship aquatic plants to markets globally. In conclusion, aquatic plants play a multifaceted role in generating economic importance for aquarium enthusiasts, commercial ventures, and beyond. From improving water quality and enhancing aesthetic appeal to supporting biodiversity and creating employment opportunities, the economic benefits of aquatic plants extend far beyond the confines of the aquarium. As interest in aquascaping and sustainable aquaculture continues to grow, the economic importance of aquatic plants is likely to increase, highlighting the need for conservation and responsible management.

An Aquarium full of aquatic plants

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Togetherness of Science and Artificial Intelligence

Anamika Paul, Research Scholar

In today's widely evolving landscape, the connection between science and artificial intelligence (AI) is proving to be transformative their way by improving the togetherness. Here's I am going to share my view on the coordination between these two domains in different aspects, those are as follows,

1. Data Collection, Automation and Optimization: Science is a broader area of generation of a vast amount of data across disciplines. AI streamlines are fully scientific processes, where AI's expertise in processing and analyzing this data unlocks new insights and make them an accumulation and correlation, acceleration of scientific discoveries, and advancements. It directly helps the researcher and learners from experimental sense development, experimental design to data analysis to focus on higher-level tasks for any experiments. This synergy boosts efficiency and enhances the pace of scientific breakthroughs.

2. Prediction and Modelling: AI-driven models can simulate complex scientific phenomena, aiding in predictive analytics and hypothesis testing. From environmental science to drug discovery, AI enhances scientific capabilities, leading to more accurate predictions and optimized outcomes. After analysis of data, AI also automatedly generates some models to present the data to encourage young ones.

3. Interdisciplinary Collaboration and Ethical Considerations: Bridging the gap between scientists and AI experts promotes interdisciplinary collaboration. The combination of these two important domains nowadays can tackle multifaceted problems and to unlock some innovative and courageous solutions that transcend the traditional barrier. Coordination between science and AI necessitates careful consideration of ethical implications. Addressing concerns such as data privacy, bias mitigation, and transparency is imperative to ensure responsible and equitable deployment of AI-driven solutions in scientific endeavours.

4. Education and Skills Development: Development of workforce equipped with both AI and scientific instruments (products) is essential for the learners to improvement of their mind set in a broader sense. So, the integration of AI education into scientific curricula and providing them some training opportunities can empower researchers to power AI effectively in their work. In all experimental cases, like statistical analysis, it is also required to done something catchy and

innovative by using AI. Only then it will be possible for the researcher and learner to improve their knowledges beyond their syllabus.

5. Long-Term Impact: As the collaboration between science and AI continues to deepen, the potential for transformative impact across various domains becomes increasingly evident. From healthcare and environmental sustainability to space exploration and satellite information, coordinated efforts hold the branch of keys to addressing complex challenges and shaping a brighter future.

In conclusion it is important to mention that encouragement in coordination between science and artificial intelligence is not just advantageous but imperative in driving innovation and addressing societal challenges. By joining the complementary strengths of these domains, we overlay the way for extraordinary advancements by decision explainability and foster in a new era of scientific discovery and technological innovation to make a scientific community.

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Illumining plant: A briefing on gene-engineered *Nicotiana benthamiana*

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Bioluminescence is the process by which living organisms produce and emit light using their own mechanism. In the form of chemiluminescence, it occurs widely in marine invertebrates and vertebrates, as well as in some fungi, bacteria, and terrestrial arthropods such as fireflies. Recently, autoluminescent plants have been engineered to express bacterial bioluminescence gene clusterin plastids (Krichevsky et al., 2010). The mechanism of light emission is conserved. The enzyme luciferase converts luciferin by oxidation into a high energy intermediate that decays to emit light (Shimomura, 2006). However, current bioluminescent reporters have some significant challenges, which limits their large-scale applications. One major challenge is uniform incorporation and penetration of the substrate of luciferin (D-luciferin), especially in adult plant tissues. But it has not been widely implemented because of low light output and relatively high cost of D-luciferin (up to several hundred dollars per gram) (Khakhar et al., 2020).

The pathway of fungal bioluminescence can be reconstructed in other organisms that allow luminescence imaging without exogenous supply of substrate. The pathway starts from biosynthesis of hispidin which is catalyzed by a large fungal polyketide synthase after a posttranslational modification. A hybrid bioluminescence pathway can be constructed using combination of plant and fungal genes for highest possible luminescence.

Caffeic acid is ubiquitously present in vascular plants which plays an important intermediary role in the phenylpropanoid pathway that facilitates the production of lignin and other metabolites (Mitiouchkina et al., 2020). Caffeic acid is synthesized through L-tyrosine biosynthetic pathway from a simple carbon source such as glucose **(Fig. 1 a)**. Recently, it has been revealed that bioluminescent fungi convert caffeic acid into luciferin to emit light **(Fig. 1 b)**. Therefore, the fungal bioluminescence pathway has been utilized to construct reporters that produce light in plants (*N. benthamiana* Domim) without incorporation of additional substrates of luciferin **(Fig. 1 c-f)** (Khakhar et al., 2020).

Phenylpropanoid biosynthesis pathway produces caffeic acid which is converted to hispidin by *HispS* (hispidin synthase) once it is post-translationally activated by *npgA* (a 4'-phosphopantetheinyl transferase of *A. nidulans*). By using *H3H* (hispidin-3-hydroxylase), hispidin is then converted to 3-Hydroxyhispidin which is a luciferin molecule. Finally, 3-Hydroxyhispidin is oxidized by luciferase (*Luz*) to a high energy intermediate that degrades into caffeoylpyruvic acid, which in turn produce light. Finally, *CPH* (caffeoylpyruvate hydrolase) can turn

caffeoylpyruvic acid back into caffeic acid thus closing the cycle (Kotlobay et al., 2018). The *npgA* was isolated from *Aspergillus nidulans*, whereas, *H3H* and *HispS* was cloned from *Neonothopanus nambi* (Kotlobay et al., 2018).

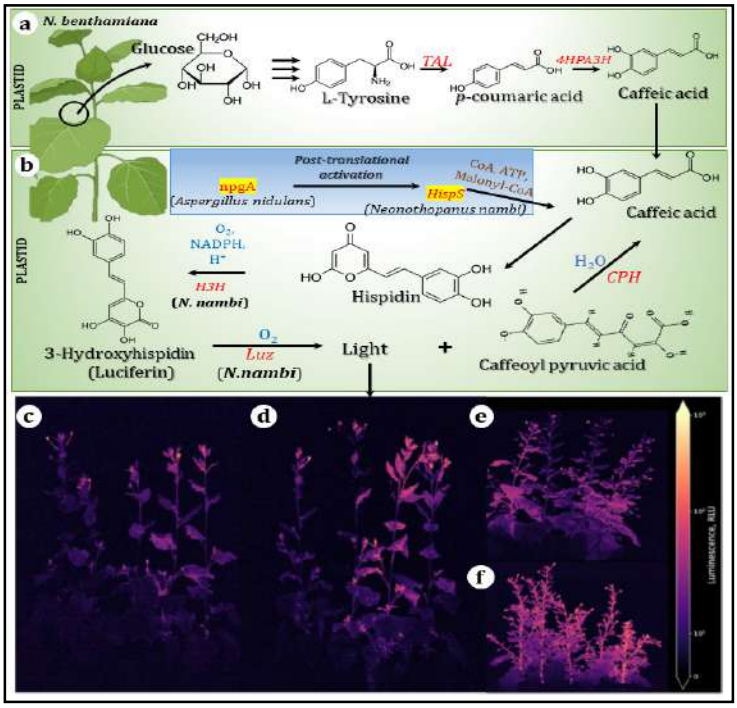

Figure 1:(a) In *N. benthamiana* caffeic acid is produced from glucose through phenylpropanoid pathway; (b) Luciferin has been oxidized by luciferase through caffeic acid cycle forming caffeoylpyruvate and light as a byproduct. This caffeoylpyruvate then recycles back to Caffeic acid; (c), (d), (e) and (f) Photographs of transgenic *N. benthamiana* (Adapted from Palkina et al. 2024) showing Bioluminescence property. Scale showing relative luminescence units (RLU).

Khakhar et al. (2020) generated a stable transgenic line of *N. benthamiana* having auto-luminescence property by stably integrating expression cassettes for the three enzymes in the biosynthesis pathway (*npgA*, *H3H*, and *HispS*), the recycling pathway (*CPH*), and the fungal luciferase (*Luz).* In plants, luminescence was signalized on rooting medium or soil, exhibiting auto-luminescence throughout the plant. Stronger signals were detected in the growing meristematic regions (root tips and shoot apices), consistently with a higher density of cells in these tissues. Younger leaves seem to have lower luminescence than older leaves, revealing there is some developmentally consistent heterogeneity in luciferin substrate biosynthesis, potentially due to variation in caffeic acid availability under different environmental conditions. These results demonstrate the possibility to create sustained auto-luminescence by producing plants with stably integrated fungal bioluminescence pathway.

By implementing autonomous light emission, vital plant processes can be monitored, which includes development, pathogenesis, response to environmental factors and consequences of chemical treatments. Additionally, bioluminescence is used by a varied set of organisms to accomplish an array of goals, such as to attract mates, scare off predators and recruit other creatures for fulfilling the purpose of reproduction. Screening techniques must be enabled by the accessibility and efficiency of obtaining luminescent data. By removing the necessity for exogenous incorporation of substrates such as luciferin, these light emitting capabilities should be specifically beneficial for experiments with plants in green house as well as field condition.

Keywords: Bioluminescence*; Nicotiana benthamiana*; Fungal luciferin; Genetically engineered; caffeic acid cycle.

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Sex determination in Plants: A review

Shinjinee Pramanik & Anshuman Jha, Semester VI

A field of research in cytogenetics that has raised inquisition among scientists is the determination of plant sex chromosomes. Unlike mammals, sex is typically determined by the presence of the Y chromosome but as for plants, they exhibit a variety of combinations like XY, XX/XY, XX/XY1Y2, ZW and environmental factors also assists the determination.

Cytogenetic mechanisms play a crucial role in determining sex in plants. Plants like *Silene latifolia* Poir. have a system similar to mammals, with males having XY and females having XX and this was inferred via karyotyping due to the difference in size. The ZW system observed in birds is also exhibited by *Carica papaya* L. where males have ZZ chromosomes and females have ZW, and it was again detected via Fluorescence in situ hybridization (FISH). Not only that, but due to the morphological difference of the autosomes from the allosomes, study of the heteromorphic chromosomes via simple cytogenetic tests also gave evidence for the same. In species of *Rumex acetosa* L., complex sex determination systems such as XX/XY1Y2 was elucidated via cytogenetic analyses which revealed chromosomal rearrangements that differentiate between X and Y chromosomes. In *Arabidopsis thaliana* (L.) Heynh., sex determination involves various genes and pathways under molecular mechanism. Sometimes, sex determination in plants like *Silene alba* (Mill.) E.H.L.Krause, is based on environmental factors such as temperature or photoperiod.

Cytogenetic studies have given us a broad aspect to know about the genes responsible for this phenomenon but the real challenge is faced when it comes to sequencing Y chromosomes in plants due to their small size, repetitive nature and often heterochromatic structure. The plant, *Silene latifolia,* is one of the first plants whose Y chromosome was sequenced. This work revealed a highly heterochromatic region responsible for evolution. Not only that, sequencing of *Rumex acetosa* and *Asparagus officinalis* L. gave details of evolutionary patterns of the Y chromosome. This also helped in solving the mystery of its monophyletic and polyphyletic origin.

Keywords: Sex determination, Karyotyping, FISH, Heteromorphic chromosomes, sex chromosomes, Cytogenetics, Genomics, Evolutionary patterns.

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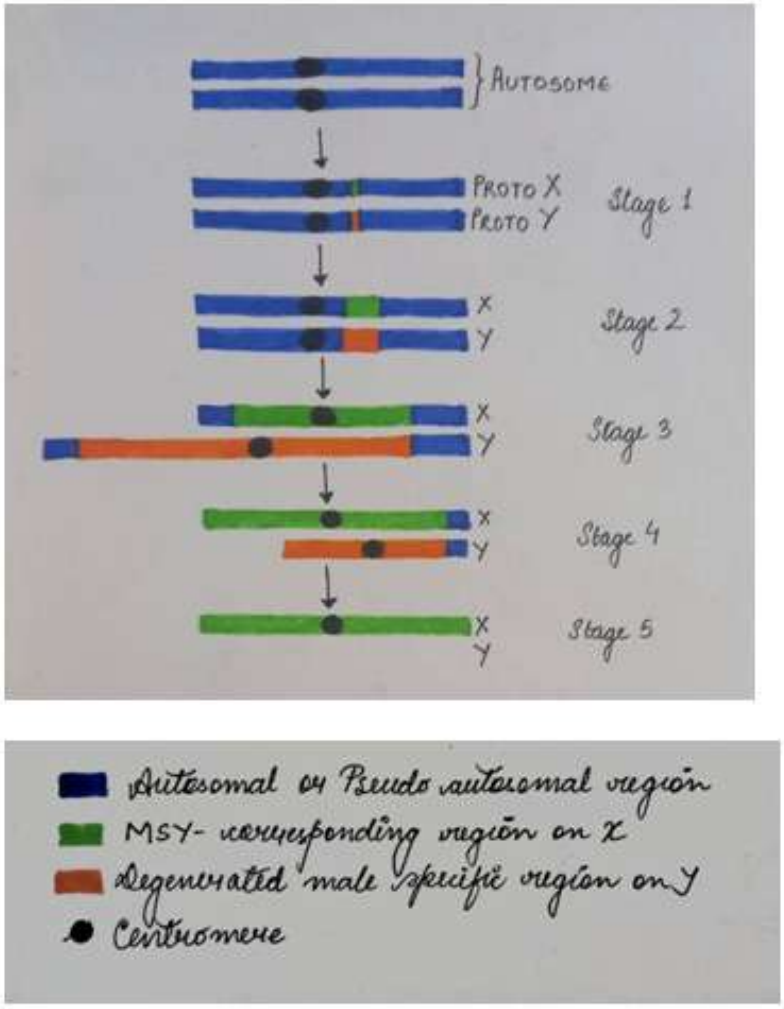
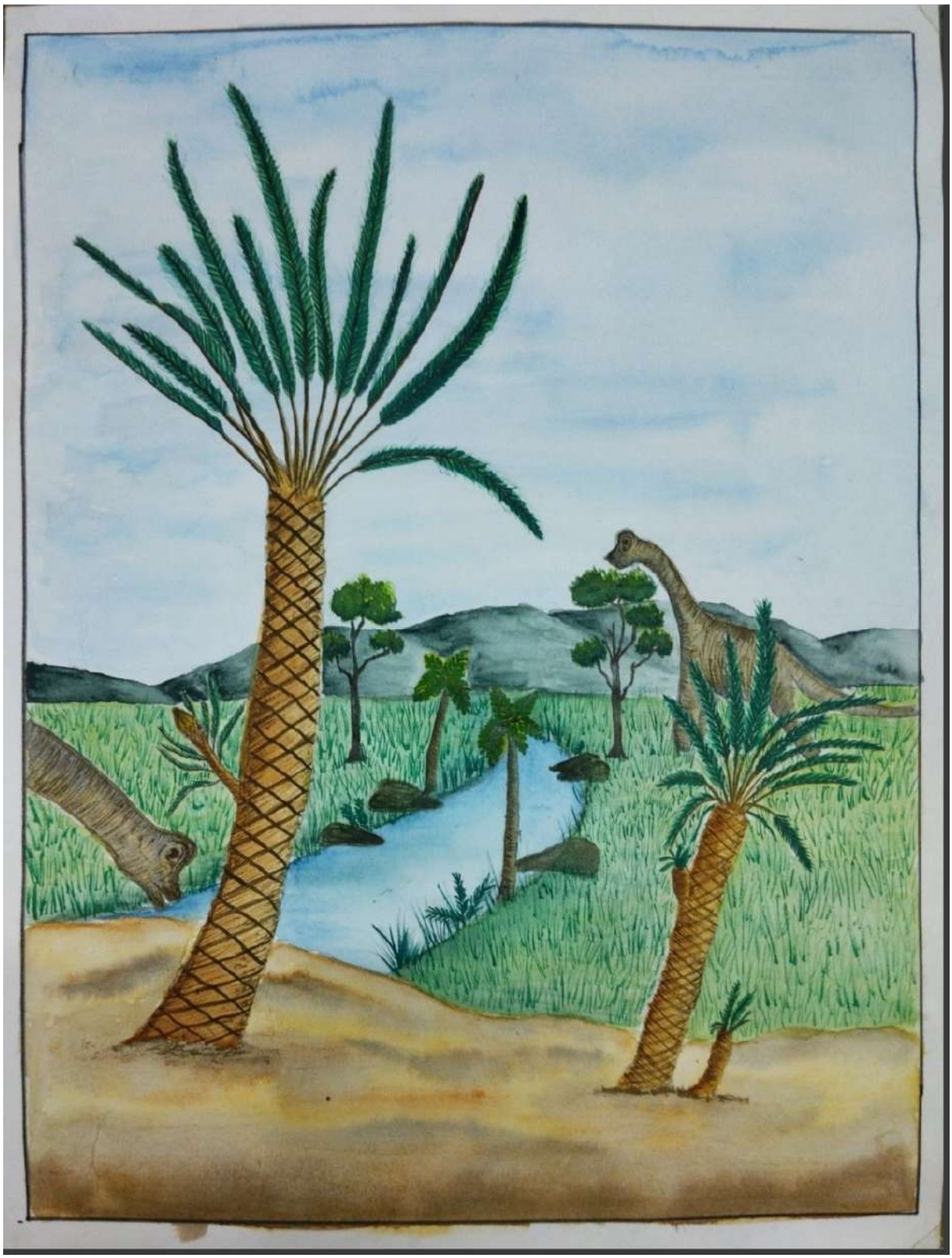


The five stages of sex chromosome evolution based on the size of the nonrecombining region, degree of degeneration, and size of Y chromosome. Illustrated by: Shubham Dutta, Semester VI

- Stage 1: Suppression of recombination at the sex determination locus and its neighbouring regions led to mild degeneration of the suppressed region. YY genotype is viable.
- Stage 2: Suppression of recombination continues to spread, and a small MSY region evolved. YY genotype is not viable.
- Stage 3: The MSY expands in size and degenerates in gene content by accumulation of transposable element insertions and intrachromosomal rearrangements. The X and Y chromosomes become heteromorphic.
- Stage 4: Severe degeneration of the Y chromosome causes loss of function for most genes. Deletion of nonfunctional DNA sequences results in shrinking of the Y chromosome in size.
- Stage 5: Suppression of recombination spreads to the entire Y chromosome. The Y chromosome is lost, and X-to-autosome ratio sex determination system has evolved.

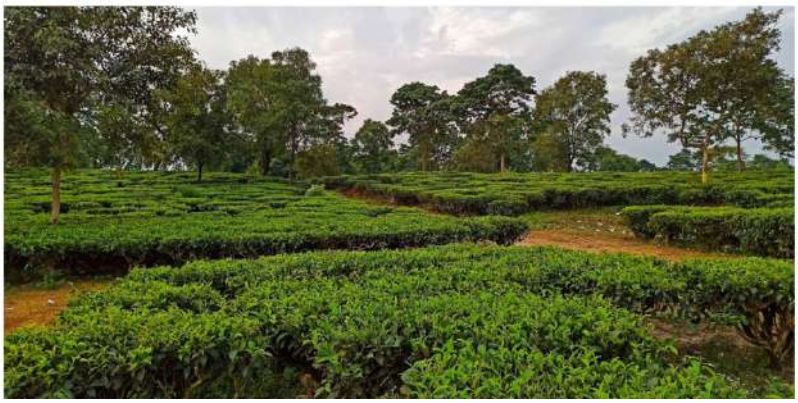


Dwaita Kundu, Semester IV

The Journey of *Camellia sinensis*

Ananya Sarkar, UG Semester IV

In the last century, tea has become a major agricultural product worldwide, and more than half of the world's population enjoys drinking it. Though it has permeated every aspect of our lives, do you know how this omnipresent beverage got its start? How is it processed? It's chemistry, and are there any health benefits or therapeutic potential in tea? Let's find out!



HISTORY AND ORIGIN

Chinese tradition states that the accidental discovery of tea [*Camellia sinensis* (L.) Kuntze] by the virtuous ruler and scientist Emperor Shen Nong took place in 2737 B.C.E. A leaf from a wild tea tree that overhangs slipped into his pot of boiling water in the garden. It is unclear exactly where tea originated geographically but thought to have come from China, India, or both. It is undeniable that tea was being grown in China as early as 2700 BC, although tea has never been discovered growing in its natural state there.

It is widely acknowledged that *Thea assamica* Mast. the wild tea tree is the progenitor of all cultivated varieties and that it was first reported to exist in the hilly regions of Assam and its neighboring areas as early as 1823. There is an assumption that Chinese explorers made it as far as Assam and returned with tea seeds to plant back home. India did not realize the immense gift that nature had given her until the 1818–1834 period, when it started experimenting with tea production using reimported Chinese tea seeds, even though wild tea was flourishing in Indian forests.

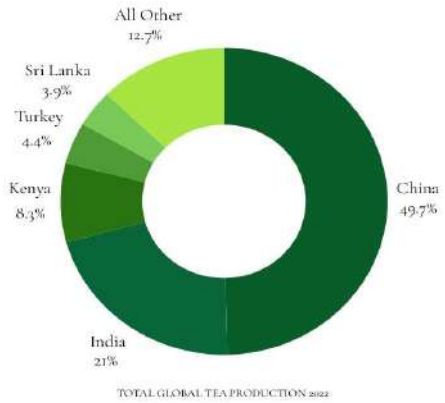
The practice of drinking tea was first established as a social ritual in China in the 5th century AD, and it was introduced to Japan in the early 8th century by Buddhist monks. However, it wasn't until the 17th century that it began to spread to other Asian nations. In the latter half of the 16th or early part of the 17th century, the Turks brought tea from China to the West. When tea originally arrived in England, the infusion was discarded and the boiled leaves were sandwiched between slices of buttered toast. Inaugurated in 1657 in Exchange Alley, London, tea houses quickly became well-known throughout the West as a superior non-alcoholic beverage.

As the greatest nation in the West to drink tea, England currently leads other nations in imports.

The tradition of consuming tea was brought to North America by English immigrants. The colonists revolted against the government because of the high taxes they were forced to pay. On December 16, 1773, they took control of a shipment of 342 chests of tea that had just arrived and emptied it into Boston Harbor. The fight of independence was started by an event known as the 'Boston Tea Party'.

TEA PRODUCTION BY MAJOR PRODUCING COUNTRIES

Data indicates that 6.4 mmt of tea were produced worldwide in 2022, with China contributing 3.2 mmt. India, the world's second largest producer, produced 1.34 mmt (21%) of the world's total tea, less than half of China's amount.



Varieties

Mainly of two types:- Chinese and Assamese Tea

The China Variety (*C. sinensis* var. *sinensis*) is a multi stemmed bush that grows as high as 2.75 meters. A hardy plant able to withstand cold winters, it has an economic life of at least 100 years.

The Assam Variety (*C. sinensis* var. *assamica* Mast.) grows as a single-stem tree, ranging from 6 to 18 meters in height. The plant has an economic life of 40 years with regular pruning and plucking.

TEA PROCESSING

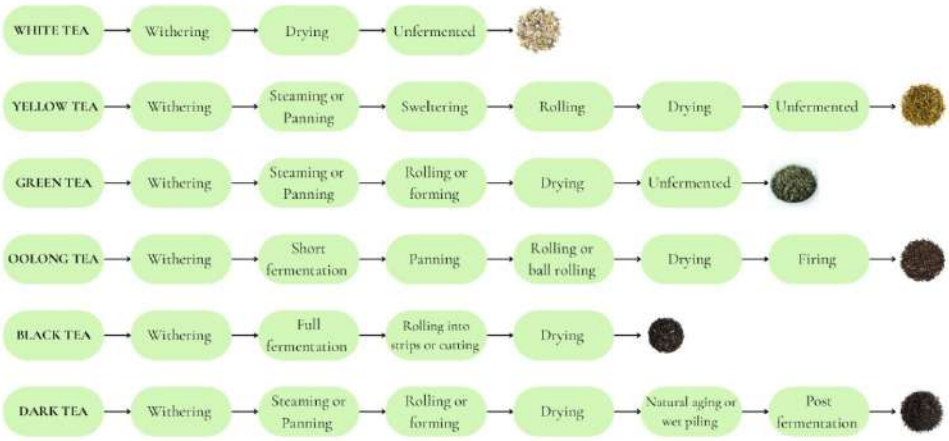
The processing of tea leaves plays a pivotal role in shaping the flavor, aroma, and appearance of the final tea product. The main processing methods include:

Withering: Freshly harvested tea leaves undergo controlled withering, where they lose moisture and become pliable. This process prepares the leaves for subsequent processing steps and initiates biochemical changes that influence the tea's flavor profile.

Oxidation: Oxidation, or fermentation, is a crucial step in the production of black and oolong teas. Enzymes within the leaves catalyze the oxidation of polyphenols, resulting in the formation of complex flavor compounds and theaflavins. The degree of oxidation determines the tea's color, flavor, and aroma.

Fixation: Fixation, also known as "kill-green" or "shaqing," halts the oxidation process by applying heat to the tea leaves. Common fixation methods include pan-firing or steaming.

According to processing, tea can be divided into **white tea**, **yellow tea**, **green tea**, **oolong tea** (also referred to as red tea), **black tea**, and **dark tea** (pu-erh).



CHEMICAL COMPOSITION OF TEA LEAVES

The most notable constituents include:

1. Polyphenols: These antioxidants contribute to the bitterness, astringency, and color of tea. The major polyphenols in tea are catechins, which include epigallocatechin gallate (EGCG), epicatechin gallate (ECG), epigallocatechin (EGC), and epicatechin (EC).

2. Caffeine: Known for its stimulant effects, caffeine is present in varying amounts in different types of tea. It enhances alertness and may improve cognitive function, contributing to tea's popularity as a morning pick-me-up.

3. Amino Acids: Theanine, an amino acid unique to tea, contributes to its savory and umami flavors. It also has relaxing effects, counteracting the stimulating effects of caffeine and promoting a sense of calmness.

4. Volatile Organic Compounds (VOCs): These compounds, responsible for tea's aroma, include terpenes, aldehydes, and ketones. VOCs contribute to the distinctive scents of different tea varieties, ranging from floral and fruity to grassy and earthy notes.

CHEMISTRY OF TEA BREWING

The process of brewing tea involves extracting various compounds from the leaves and dissolving them in water. Factors such as temperature, brewing time, and water quality influence the chemical reactions that occur during brewing.

1. Extraction of Caffeine and Polyphenols: Hot water facilitates the extraction of caffeine and polyphenols from tea leaves. Longer brewing times and higher temperatures result in higher concentrations of these compounds in the brewed tea.

2. Oxidation: Oxidation, a natural process that occurs when tea leaves are exposed to oxygen, affects the flavor and color of the brewed tea. Green teas are minimally oxidized, resulting in a light, grassy flavor, while black teas undergo complete oxidation, yielding a robust, malty taste.

3. pH Effects: The pH of the brewing water can influence the extraction of certain compounds and the overall flavor profile of the tea. Slightly acidic conditions enhance the extraction of catechins, while alkaline conditions may lead to a smoother, less astringent brew.

CHEMICAL CHANGES DURING STEEPING

Catechins undergo hydrolysis during steeping, resulting in the formation of more complex flavonoids and theaflavins in black and oolong teas. These compounds contribute to the rich color and flavor of brewed tea.

Volatile compounds responsible for tea's aroma can degrade over time, especially at higher temperatures. Proper steeping techniques, such as using lower water temperatures and shorter brewing times, help preserve these delicate aromas.

Recent research on Camellia sinensis has continued to uncover its diverse health benefits. Here are some notable areas of study:

Antioxidant and Anti-inflammatory Properties: Several studies have confirmed the potent antioxidant and anti-inflammatory effects of *Camellia sinensis*, particularly its polyphenol content. Research indicates that tea consumption may help reduce oxidative stress, inflammation, and the risk of chronic diseases such as cardiovascular disease, cancer, and neurodegenerative disorders.

Neuroprotective Effects: Theanine, an amino acid abundant in tea, has gained attention for its neuroprotective properties. Research indicates that theanine may enhance cognitive function, reduce stress and anxiety, and promote relaxation without sedation. These findings have implications for mental health and well-being.

Green Tea Extracts in Cancer Therapy: Green tea extracts, particularly epigallocatechin gallate (EGCG), have attracted attention for their potential anticancer properties. Recent studies have explored the mechanisms by which EGCG exerts its anticancer effects, including inhibition of tumor cell proliferation, induction of apoptosis, and modulation of signaling pathways involved in cancer development and progression.

The *Camellia sinensis's* journey from leaf to cup is an example of human creativity and appreciation for the wonders of nature. With the progress of research, our comprehension of the chemistry of tea and its health benefits broadens, guaranteeing that this age-old Infusion persists in captivating and enhancing lives around.

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Food of the Gods: Its Health Benefits, Genome Sequencing and Global Import

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Keyword: cacao beans, chocolate, polyphenols, flavonoids, import

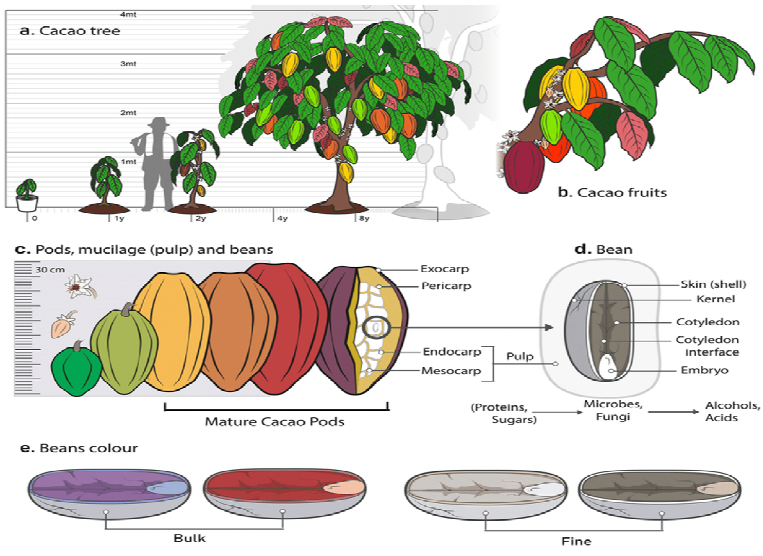
Cacao beans, which originate from the Amazon Rainforests have sprouted to showcase one of the most widely grown crops for its high worth on an economic scale. *Theobroma cacao* L. (Malvaceae) was first domesticated more than 5,000 years ago in the equatorial regions of South America. Often referred to as The Food of the Gods, cocoa beans serve as the source for products such as cocoa solids, cocoa butter, and of course our best friend, chocolate! In addition to these, cocoa beans are of huge importance in cosmetic and pharmaceutical industries. Rich in polyphenolic antioxidants, especially the high flavonoid content of the beans has been proven to be beneficial for human health. These polyphenols have cancer preventing powers due to the presence of chemo-preventive agents. Extracted flavonoids are found to be crucial in mediating innate and acquired immunity, along with its cardioprotective agents. Their positive impact on diet induced obesity and insulin resistance is noteworthy. The International Cocoa Genome Sequencing Consortium (ICGS), coordinated by CIRAD, presented an in-depth analysis of the genomic sequence of the Criollo cocoa variety. The genome sequence revealed 28,798 protein-coding genes, with approximately 20% of the cacao genome composed of transposable elements. Several genes were identified that code for flavonoids, aromatic terpenes, theobromine, and numerous other metabolites contributing to cocoa flavour and quality traits. Notably, a significant number of these genes were found to encode polyphenols, which make up as much as 8% of the dry weight of a cacao pod. Using CRISPR/Cas9 to knock out the cacao Non-Expressor of Pathogenesis-Related 3 (TcNPR3) gene, identified by Fister and his colleagues as a suppressor of the defence response in cocoa, could enhance disease resistance. This gene editing, facilitated by *Agrobacterium tumefaciens* as the delivery vehicle, would make genetically modified cocoa plants more resilient to black pod disease caused by *Phytophthora* species. Black pod disease is a major limiting factor in global cocoa production. The sgRNA is the main driver for gene insertion or deletion. It primarily consists of a customized crRNA sequence attached to a backbone structure known as the tracrRNA sequence. The sgRNA fragment can be designed manually or synthesized in vivo or in vitro. The specificity of the Cas9 nuclease is determined by the 20-nt guide sequence within the sgRNA. A potential target sequence must immediately precede the PAM (5′-NGG-3′) to be recognized by the first 20-nt of the sgRNA via Watson-Crick base pairing. This recognition between the sgRNA and its target leads to Cas9 cleavage 3 bp upstream from the PAM. In the global trade of cocoa beans, several countries stand out as major import markets. These countries play a crucial role in the supply chain of cocoa beans, the key ingredient in chocolate production. The Netherlands leads as the world's largest importer of cocoa beans, with an import value of

Cacao Tree (*Theobroma cacao*)
(Picture courtesy: bioweb.uwlax.edu)

$2.2 billion USD in 2023, owing to its high demand in the chocolate andconfectioners' industries. It I closely followed by Malaysia, Germany, Belgium, USA, Indonesia, Canada, France, Italy and Turkey.

Half cacao pods with cacao fruit and brown cocoa powder
(Picture courtesy: stock images)

Cacao pods on a tree
(Picture courtesy: chocmod.in)



Representation of a Cacao tree and parts of a cacao bean

(Picture courtesy: researchgate.net/figure)

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Part V Information and knowledge testing pages on 'Botany'

Few of the prime institutes for plant science research

Sl no.	Institute	Programme
1.	The CSIR-National Botanical Research Institute (NBRI)	Ph.D
2.	Botanical Survey of India, Howrah	PhD
3.	CSIR-Central Institute of Medicinal and Aromatic Plants (CSIR-CIMAP), Lucknow	Training, PhD
4.	Birbal Sahni Institute of Palaeosciences, DST, Lucknow	Training for UG and PG students, Masters dissertation projects, PhD
5.	The National Institute of Plant Genome Research, DBT	Ph.D, Trainings
	The ICAR Institutes	
6.	Indian Agricultural Research Institute, ICAR	PG, PhD
7.	ICAR-Central Institute of Cotton Research, Nagpur	PhD
8.	ICAR-Central Potato Research Institute, Shimla	PhD
9.	ICAR-Central Research Institute for Jute and Allied Fibres, Barrackpore	PhD
10	ICAR-National Rice Research Institute, Cuttack	PhD
11	ICAR-Central Tobacco Research Institute, Rajahmundry	PhD
12	ICAR-Central Tuber Crops Research Institute, Trivandrum	PhD
13	ICAR-Indian Institute of Agricultural Biotechnology, Ranchi	PhD
14	ICAR-Indian Institute of Horticultural Research, Bengaluru	PhD
15	ICAR-Indian Institute of Pulses Research, Kanpur	PhD
16	ICAR-Indian Institute of Spices Research, Calicut	PhD
17	ICAR-Indian Institute of Sugarcane Research, Lucknow	PhD
18	ICAR-Indian Institute of Vegetable Research, Varanasi	PhD
19	ICAR-Indian Institute of Maize Research,Ludhiana	PhD
20	ICAR- Indian Institute of Wheat and Barley Research, Karnal	PhD
21	ICAR- Indian Institute of Millets Research, Hyderabad	PhD
22	ICAR- Indian Institute of Oilseeds Research, Hyderabad	PhD
23	ICAR-Central Citrus Research Institute, Nagpur	PhD
24	Institute of Wood Science & Technology, ICFRE, Bengaluru	Phd, PG Diploma, Trainings

Online Public Resources for Plant Research: Websites for 'budding' scientists

Agnik Bhattacharya, UG Semester – IV, agnikbhattacharya04@gmail.com

In the 21st century, botanical research is not just limited to field studies, specimen collections, diagrams, descriptions, and journals. Modern research in the plant sciences now often involves a huge amount of data that needs to be collected, analyzed, and processed into tabular or graphical representations. Thus, Artificial intelligence (AI) and machine learning are increasingly being used to help scientists in their pursuits.

Dusty textbooks and endless index card searches in the library are a thing of the past. The internet has blossomed into a vibrant ecosystem of resources, with a large amount of information easily accessible to people that help students and researchers' reference, corroborate, and cross-check their collected data. All of there sources listed below are free to use and are thus ideal for independent researchers who are just starting or those who have limited funding.

Taxonomic Research:

- *Botanical Survey of India (BSI) Digital resources*: [https://bsi.gov.in/page/en/digital-resources] includes indispensable references in the form of Indian Virtual Herbarium, e-Flora of India and PDFs of rare books and current journals.
- *IPNI (International Plant Names Index)*: [www.ipni.org] provides nomenclatural data (spelling, author, types and first place/date of publication) for the scientific names of vascular plants from family to infraspecific ranks.
- *The Plant List: [www.plantlist.org]* is a working list of all known plant species and is useful to use in conjunction with IPNI as it includes mosses and liverworts.
- *POWO: Plants of the World Online* [https://powo.science.kew.org/] is an international collaborative programme by Royal Botanic Gardens, Kew, that makes available digitized data of the world's flora gathered from the past 250 years of botanical exploration and research.All data incorporated into POWO are attached to the currently accepted name from the WCVP (World Checklist of Vascular Plants) names backbone.
- *The International Code of Nomenclature for algae, fungi, and plants* [https://www.iapt-taxon.org/nomen/main.php] is the set of rules and recommendations that govern the scientific naming of all organisms traditionally treated as algae, fungi, or plants, whether fossil or non-fossil,

including blue-green algae (Cyanobacteria), chytrids, oomycetes, slime moulds, and photosynthetic protists with their taxonomically related non-photosynthetic groups. This edition of the Code embodies the decisions of the Nomenclature Section of the XIX International Botanical Congress (IBC), which took place in Shenzhen, China in July 2017.

- *Index NominumGenericorum:* [https://naturalhistory2.si.edu/botany/ing/] gives nomenclatural data for generic names.

- *Index Fungorum* [www.indexfungorum.org] gives nomenclatural data for fungal species.

- *Index Herbariorum* [https://sweetgum.nybg.org/science/ih/] for addresses and codes of major herbaria across the world.

- *IFPNI (The International Fossil Plant Names Index)* [www.ifpni.org] is a comprehensive literature-based record of the scientific names of all fossil plants, algae, fungi, allied prokaryotic forms, protists) and microproblematica. IFPNI documents all nomenclatural novelties (new scientific names of extinct organisms) and associated data, including registration of the scientific publications containing nomenclatural acts and authors generated taxonomic literature in paleobotany and paleontology in general.

- *The Tropicos database* [www.tropicos.org]s is an online botanical database containing taxonomic information on plants, mainly from the Neotropical realm. It is maintained by the Missouri Botanical Garden and was established over 25 years ago. The database contains images and taxonomical and bibliographical data on more than 4.2 million herbarium specimens. In addition, it contains data on over 49,000 scientific publications. It is also useful for finding ethnobotanical applications of plants across the world.

- *BrassiBase* [https://brassibase.cos.uni-heidelberg.de/] documents information and research related to species within the plant family Brassicaceae. It is hosted by the University of Heidelberg. The website provides tools and biological resources for Brassicaceae character and trait studies and is used to refine the taxonomy and evolutionary history of plants in this family and to perform phylogenetic analyses.

- *GrassBase – The Online World Grass Flora*[www.kew.org/data/grasses-db.html] is a web-based database of grasses, continually maintained and updated by the Royal Botanic Gardens, Kew. It is one of the largest structured datasets for plants and has morphological descriptions for 11,369 accepted species of grasses and listings for 64,213 botanical names.

Genetic Research

- *IPCN (*The *Index to Plant Chromosome Numbers):* [http://legacy.tropicos.org/Project/IPCN] aims to extract and index original plant chromosome numbers of naturally occurring and cultivated plants published throughout the world.This project is based at the Missouri Botanical Garden and has been operative since 1978. The chromosome data is available for taxa from the family level to the species level.
- *CCDB (Chromosome Counts Database) [*(http://ccdb.tau.ac.il/] was assembled IN 2015 as an online unified community resource. This database compiles dozens of different chromosome counts sources, of which a significant portion had been unavailable before in a digitized, searchable format.
  Chromosome count has been used as an important phylogenetic marker and as an indicator for major genomic events such as polyploidy and dysploidy.
- *The Plant DNA C-values Database* (https://cvalues.science.kew.org/) is a comprehensive catalogue of C-value (nuclear DNA content, or in diploids, genome size) data for land plants and algae. The database was originally launched as the "Angiosperm DNA C-values Database" in April 1997, essentially as an online version of collected data lists that had been published by Royal Botanic Gardens, Kew.
- *Genesys* [www.genesys-pgr.org] is an online, global portal about Plant Genetic Resources for Food and Agriculture (PGRFA) conserved in gene banks worldwide. It is a gateway from which germplasm accessions from gene banks around the world can be easily found and ordered.

- *GRIN (Germplasm Resources Information Network)*[www.ars-grin.gov]is an online USDA National Genetic Resources Program software project to comprehensively manage the computer database for the holdings of all plant germplasm collected by the National Plant Germplasm System. The site is also a resource for identifying taxonomic information (scientific names) as well as common names on more than 500,000 accessions (distinct varieties, cultivars etc.) of plants covering 10,000 species both economically important ones and wild species and profiles plants that are invasive or noxious weeds, threatened or endangered, giving out data on worldwide distribution of its habitat, etc.

- *TAIR (The Arabidopsis Information Resource)*[www.arabidopsis.org] is a community resource and online model organism database of genetic and molecular biology data for the model plant *Arabidopsis thaliana*, commonly known as mouse-ear cress. TAIR integrates information about the Arabidopsis genome, genes, gene products, natural variants, mutant alleles and plant phenotypes and research literature.

Molecular and Cellular Biology research

- *The European Bioinformatics Institute Database (EMBL-EBI)* [www.ebi.ac.uk] which, as part of the European Molecular Biology Laboratory (EMBL), provides freely available data and bioinformatics services by maintaining the world's most comprehensive range of molecular data resources. It is an

index of biological data in a set of databases, which includes whole genome sequence data, protein sequence and nucleic acid tertiary structure database. A variety of online services and tools are also provided, which enable further data analysis.

- *The UniProt Knowledgebase (UniProtKB)* [www.uniprot.org] is the central hub for the collection of functional information on proteins, which are either manually ('Swiss-Prot') or automatically ('TrEMBL') annotated. It mainly stores the amino acid sequence, protein name or description, taxonomic data, and citation information of a protein with ontologies, classifications and cross-references and has specialized functions like 'Peptide Search' and 'SPARQL.'
- *STRING* [https://string-db.org] is a database of known and predicted protein-protein interactions which include direct (physical) and indirect (functional) associations. They mainly stem from computational prediction, knowledge transfer between organisms, and from interactions aggregated from other primary databases (like UniProt). The database currently covers 59,309,604 proteins from 12,535 organisms.
- *Cellosaurus* [www.cellosaurus.org] is an online knowledge base on cell lines, which attempts to document all cell lines used in biological research. It is provided by the Swiss Institute of Bioinformatics (SIB) and contains information for more than 1,44,000 cell lines. It is mainly composed of manually curated information and for each cell line it lists a recommended name, synonyms and the species of origin along with an accession number.
- *Rhea* [www.rhea-db.org] is an expert-curated knowledgebase of chemical and transport reactions of biological interest and is the standard for enzyme and transporter annotation used in UniProtKB. Rhea uses the chemical dictionary ChEBI (Chemical Entities of Biological Interest) to describe reaction participants. It also has niche functions like 'Structure search' where a molecular structure can be drawn and all the relevant information about the molecule can be retrieved.

With the advent of new technologies, high throughput biological data from genomics, transcriptomics, and other "omics" approachesis accumulating at an unprecedented rate, thus, escalating the need to incorporate 'big data' technology to manage such humongous amounts of data and increasingly this work is being delegated to Artificial Intelligence or AI. AI can sift through this data, identify patterns and connections that are difficult and time consuming for humans to discern which in turn helps researchers understand how genes, proteins, and metabolites interact to influence plant growth, development, and abiotic stress responses. AI is also being used to detect phenotypes and is also enabling scientists to experimentally replicate what happens during and after landmark genetic events like the natural speciation of a hybrid polyploid species.

Therefore, it is becoming increasingly important for researchers to be able to process data efficiently for their research in Botany and it is hoped that the knowledge bases mentioned in this article give the reader a sneak-peek into the rich tapestry of online public resources waiting to be explored and exploited for the advancement of plant sciences.

Part V Information and knowledge testing pages on 'Botany'

Solve it with Botany- -Parikh Guha Roy, UG Semester – IV

1. **Select the wrong combination-**

	Name of the plant	**Family**	**Characteristic feature**
A	*Cardanthera triflora*	Acanthaceae	Leaves showing phenotypic plasticity
B	*Fragaria vesca* (wild strawberry)	Rosaceae	Female heterogamety (ie ZW-ZZ type of sex determination)
C	*Ocimum sanctum*	Lamiaceae	Verticellaster infloresence
D	*Gossypium herbaceum*	Malvaceae	Reniform anther.

2. Assuming in a hypothetical situation, wherea replication event produces three dsDNAs from a single dsDNA. If the initial number of template dsDNA is seven, then what will be the number of dsDNA after four rounds of replication?

A) 112 B) 7 C) 567 D)1000

3. Total number of chromosomes in the leaf of *Gnetum*(a gymnosperm) is 44 . What is the expected number of chromosomes in its endosperm?

A) 22 B) 66 C) 44 D) 66 or more

4. Choose the correct set from which we can expect cells with haploid set of chromosomes –

I) Endosperm of *Cocos nucifera.* II) Pollen mother cell of *Pinus roxburghii.*

III) Egg cell in *Marchantia nepalensis.* IV) Endosperm of *Cycas pectinata*.

V) Somatic cells of *Oedogonium iyengarii.* VI) A single cell of *Salmonella typhi.*

VII) Tapetum layer in anthers . VIII) Meristematic cells of *Polygonum* sp.

A) I, II, IV, VIII B) III, IV, V, VI C) III, IV, VII, VIII D) I, II, VI, VII

5. A *Nepenthes* plant looses its leaf modification (for trapping insects) due to some mutation, which among the following biomolecule in the plant would likely to be affected the most?

A) lipids B) mannose C) cellulose D) protein

6. A pathogen in which the entire body of the organism act as an inoculum is-

A) *Xanthomonas campestris* B) *Puccinia graminis* C) *Phytophthora infestans* D) *Claviceps purpurea*

7. Which of the following organism shows diplontic life cycle?

A)Funaria B) Volvox C)Fucus D)Ectocarpus

8. In which of the following plants bicollateral vascular bundles are found in their stem-

A)*Butea monosperma*B)*Oxalis corniculata*C)*Coccinia grandis*D)*Tinospora cordifolia*

9. An odourless plant produces flowers with brightly coloured petals; usually, the plant shows anemophily. Due to some mutation, it loses its ability to produce coloured petals, thus producing flowers with unattractive small white petals. After some generations, the variation of the plant from the initial plant (with coloured flowers) is expected to -

A) increase B)decrease C) remains same D) first increase then decreases

10.The following table gives the name of the plant and their numbers in differentregions (A , B ,C & D) , choose the region which shows greatest biodiversity -

(A)	
Betula sp.	23
Cycas sp.	24
Equisetum sp.	23
Marchantia sp.	25

(B)	
Selaginella sp.	21
Riccia sp.	5
Dryopteris sp.	6
Abeis sp.	8

(C)	
Pinus sp.	39
Cycas sp.	36
Cymbopogon sp.	35
Riccia sp.	34

(D)	
Shorea robusta	32
Tectona grandis	34
Ficus religiosa	35
Tinospora sp.	36

11. According to Bentham and Hooker system of classification, *Oxalis corniculata* L. comes under which family?

A) Oxalidaceae B) Dilleniaceae C) Onagraceae D) Geraniaceae

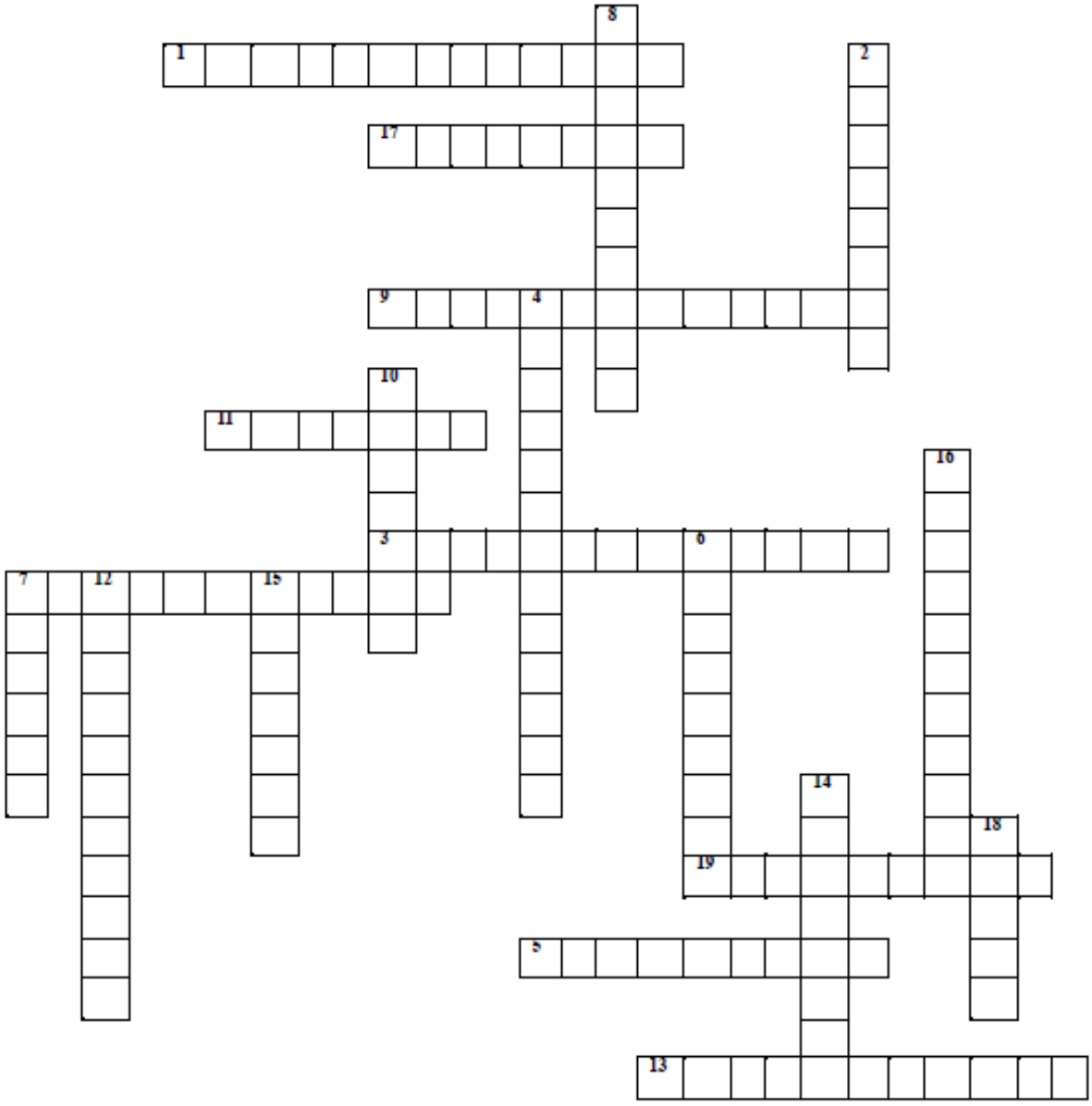
12. A student went on an excursion to an excavation site where he found a petrified fossil stem of a pteridophyte with prominent canal like structure near its pith cavity formed by disintegrated protostele with endarch siphonostelic xylem. What is likely to be the class of the fossil pteridophyte?

A) Lycopsida B) Sphenopsida C) Filicopsida D) Rhyniopsida

Part V Information and knowledge testing pages on 'Botany'

CROSS-WORD FRAME

-Dipayan Bhattacharya, UG Semester – IV



Here are your clues!!

ACROSS

1. Process of induction of plant flowering process by exposure to prolonged cold temperatures (13)
3. Arrangement of flowers on a stalk (13)
5. Interaction between two different organisms living in close association usually benefitting each other (9)
7. Flask shaped multicellular female reproductive organ present in bryophytes, pteridophytes and gymnosperms (11)
9. Process in which water is lost as water vapour from the aerial parts of the plants through stomata (13)
11. Minute pores present on surfaces of leaf helping in gaseous exchange (7)
13. Process of converting mRNA to protein (11)
17. Region of highest cell division in plants (8)
19. Nutritive tissue which acts as a food reservoir for the developing embryo (9)

DOWN

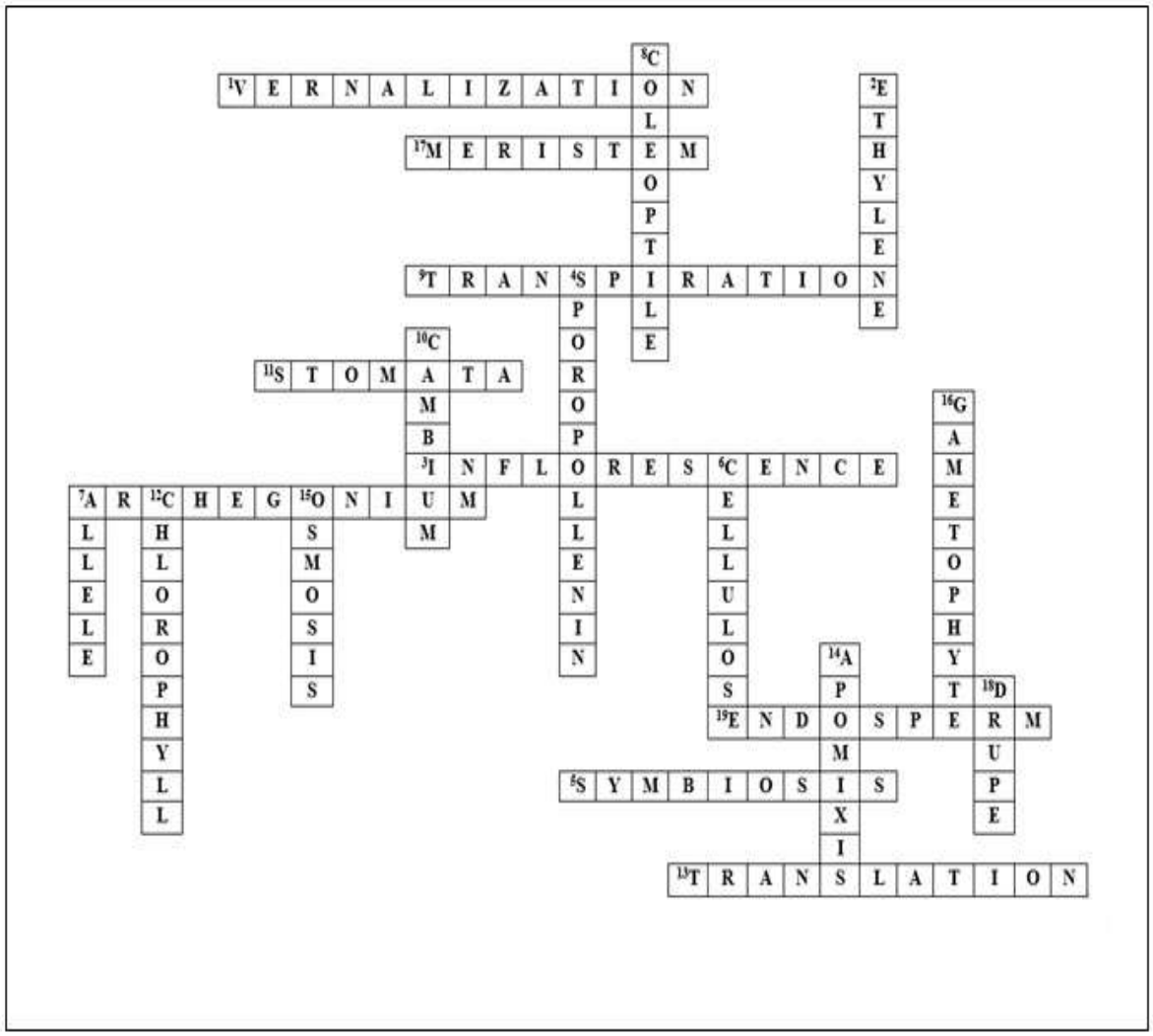
2. A gaseous plant hormone that promotes fruit ripening and other processes (8)
4. Most resistant organic compound found in the outer wall of pollen grains (13)
6. Primary constituent of plant cell wall (9)
7. Alternate forms of a gene (6)
8. A sheath protecting a young shoot tip in a grass or cereal (10)
10. Layer of tissue that produces secondary vasculature tissues (7)
12. Green pigment present in all plants and cyanobacteria responsible for carrying out photosynthesis (11)
14. Type of asexual reproduction in plants that mimics sexual reproduction but produces seeds without fertilization (8)
15. Movement of water from region of high concentration to low concentration (7)
16. Haploid stage in the life cycle of a plant (11)
18. A fleshy fruit with thin epicarp with fleshy or fibrous mesocarp and stony endocarp (5)

Solve it with botany keys:

1)C 2)B 3)D 4)B 5)D6)A

7)C 8)C 9)C 10)A 11D 12)B

Crossword key



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