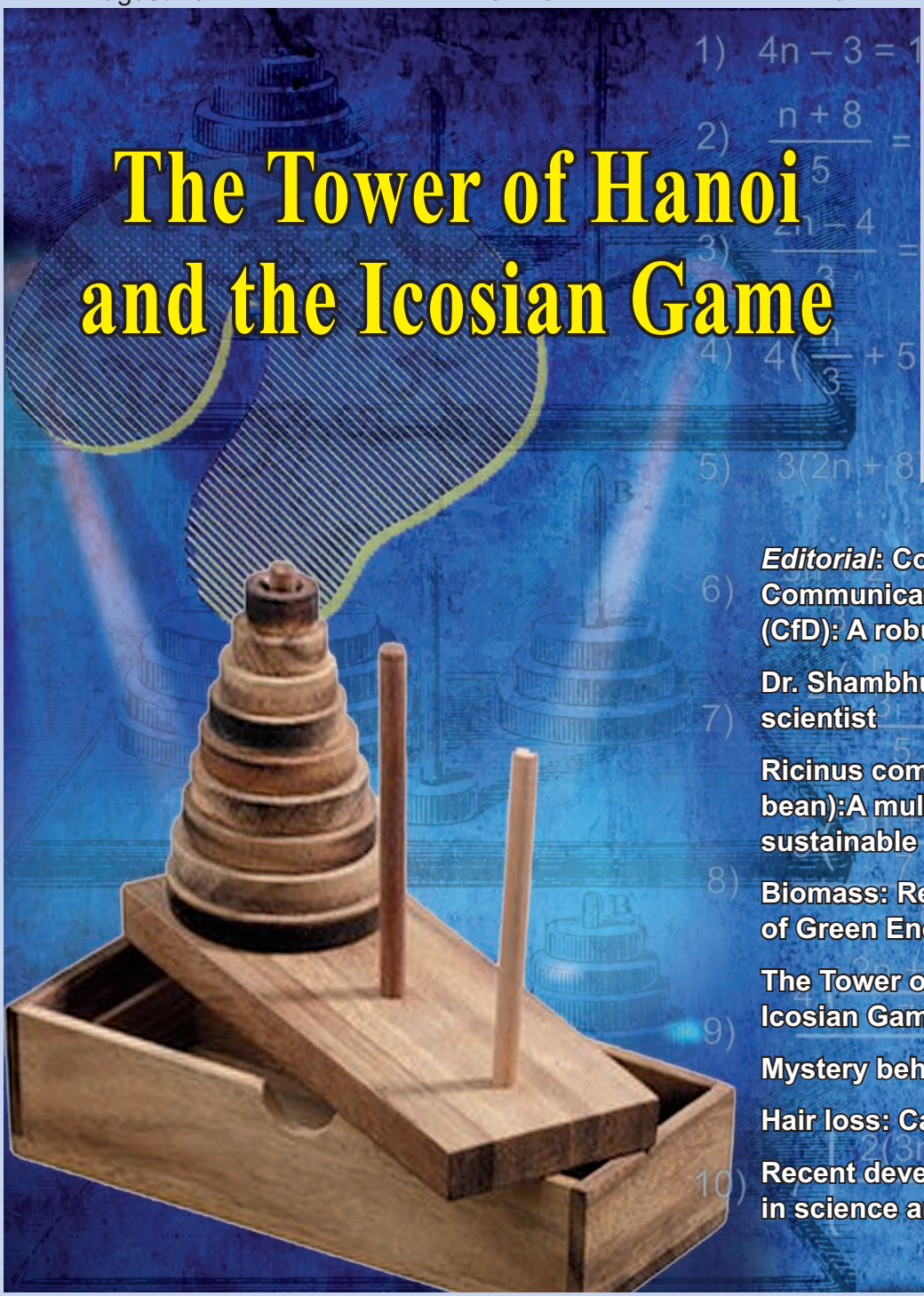
R.N. 70269/98
ISSN : 0972-169X

Postal Registration No.: DL-SW-1/4082/12-14
Date of posting: 26-27 of advance month
Date of publication: 24 of advance month

Vigyan Prasar

DREAM 2047

August 2014 Vol. 16 No. 11 Rs. 5.00



The Tower of Hanoi and the Icosian Game

Dr. Shambhunath De
(The unsung scientist)

(1915-1985)

... think scientifically, act scientifically... think scientifically, act scientifically... think scientifically, act...

Constructive dialogue in Communication for Development (CfD): A robust approach

Dr. R. Gopichandran

The objective of this editorial is to place some interesting learnings my colleagues and I gathered recently about the dynamics of science and technology communication. This is part of an on-going process within Vigyan Prasar to enrich our understanding of the process of engagement; central to the success of initiatives that serve our related national and international agenda in this regard. We were working on strategies to communicate about technologies that reduce drudgery in farm operations in the context of the present International Year of Family Farming. Interesting questions regarding the spread and depth of stakeholder engagement prompted us to look for information on challenges in science and technology communication and parameters if any. We could access four important references and useful insights and wish to indicate them for the benefit of fellow professionals engaged in science and technology communication.

The first is the Technical Paper titled 'Constructive Dialogue Communication for Development in Water, Sanitation, and Infrastructure Projects 2011 of the WSP and the World Bank (IBRD) (48p http://www.wsp.org/sites/wsp.org/files/publications/WSP-LAC-Communication-Development-Water-Sanitation-Infrastructure-TP.pdf). Specific characteristics of CfD vis-a-vis other kinds, the Rome Consensus on Communication 2006, implications of the diffusion and dialogue models of communication, and importantly the process cycle that embeds CfD phases are defined. The specific focus of the dynamics of these aspects is water, sanitation and infrastructure projects. Useful inferences on their relevance to other thrust areas and local contexts can however be derived. This publication should however be part of the collection of essential readings for communicators. Basic information regarding the unfinished agenda with special reference to water can be gathered from (http://www.un.org/waterforlifedecade/swm_cities_zaragoza_2010/pdf/facts_and_figures_long_final_eng.pdf) Water and Cities Facts and Figures, in this regard.

The Sanitation and Hygiene Advocacy and Communication Strategy Framework 2012-2017 published by the Ministry of Drinking Water and Sanitation, Government of India and the UNICEF (http://www.wsscc.org/sites/default/files/publications/sanhygadvcommstrat_2012-2017_11-09-2012_final_2.pdf) and the Drinking Water Advocacy and Communication Strategy Framework 2013-2022 (http://indiasanitationportal.org/sites/default/files/DWACS_communication_strategy_and_framework_2013_2022.pdf) help contextualise learnings from the above cited.

Initiatives centred on such aspects as sanitation and water provide direct and immediate windows of opportunity for focussed science and technology communication to enhance quality of life. Empirical evidences regarding positive impacts and consensus on limitations and initiatives to overcome them are probably the most robust platforms for mutually reinforcing sensitisation on scientific thinking for collective and well informed action.

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e-mail : info@vigyanprasar.gov.in
website : http://www.vigyanprasar.gov.in

Published and Printed by Dr. Subodh Mahanti on behalf of Vigyan Prasar, C-24, Qutab Institutional Area, New Delhi - 110 016 and Printed at Aravali Printers & Publishers Pvt. Ltd., W-30, Okhla Industrial Area, Phase-II, New Delhi-110 020 Phone: 011-26388830-32.

Dr. Shambhunath De:
The unsung scientist

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The year 2014-15 will be the birth centenary of Dr. Shambhunath De – a legend in the field of cholera research. He had devoted his life in this field without getting proper recognition from his own countrymen. No educational institution of this country honoured him with any fellowship or medal except the Coates Medal from Calcutta University in 1956. Professor Padmanabhan Balaram wrote in the editorial of the special issue of *Current Science* on Shambhunath De: "De died in 1985 unhonoured and unsung in India's scientific circles. That De received no major award in India during his lifetime and our Academies did not see it fit to elect him to their Fellowships must rank as one of the most glaring omissions of our time. De emerges, in retrospect, as a modest self-effacing scientist driven by inner compulsions to grapple with a major scientific problem of the time. His choice of cholera as his field of interest was remarkably appropriate to his setting. To this problem De brought a wonderfully thoughtful approach, together with deep intuition, enabling him to make the long-awaited breakthrough in the field. De's heroic story of persistence, dedication and achievement should serve as an inspiration to the many who are increasingly bewildered by the current fashion of mega projects, surrounded by fanfare and publicity and most often surprisingly little discernible scientific output." This article is a tribute to this unsung great hero.

Shambhunath De was born on 1 February 1915 in Garibati, a small village of Bengal near the bank of Hoogly, about 30 kilometres from Kolkata. His father was Dasharathi De and mother was Chitreswari Debi. Once their family was renowned for business, but due to repeated floods his grandfather lost all his wealth and died, leaving his widow and two sons and two daughters. Dasharathi was the eldest. So he had to take all the responsibility of the family which forced him to take a job in a groceries shop. At last he himself started a small shop but could not develop his business. Naturally Shambhunath had to face a lot of hardship in his early days. However, in spite of the poor financial condition, his uncle supported him to complete his graduation and has great impact on young Shambhunath.

Dr. Shambhunath De

Shambhunath completed his matriculation from Garibati High School with a scholarship. This scholarship helped him to get admission in Hoogly Mohsin College. From there he completed his Inter-science with another scholarship. He was selected for Calcutta Medical College, but the meagre amount of the scholarship was not sufficient to meet his expenditure at Kolkata. At that time K.C. Seth of their locality came forward to help Shambhunath. Mr. Seth had a small office-come residence in Kolkata. He offered free boarding there for Shambhunath. For this reason Shambhunath enrolled in Calcutta Medical College. Very soon he managed the free studentship there and shifted to the college hostel.

In Calcutta Medical College, Shambhunath soon drew the attention of Prof. M. N. Dey, who made no mistake in identifying this jewel. Prof. Dey had great affection for him and used to inspire him in almost all aspects. Not only that, he encouraged Shambhunath in research work too. Although there was marked difference in cultural and economic status between them, still Prof. Dey decided to make Shambhunath his son-in-law. Shambhunath married Charubala, the eldest daughter of Prof. Dey.

Shambhunath completed his MB exam in 1939 and then completed his diploma in tropical medicine from Calcutta Medical College in 1942. In the same year he was selected as demonstrator in the pathology department of Calcutta Medical college under Prof. B.P. Trivedi. In addition, he had to do some private practice too; to maintain his family in Kolkata as well in the village. The work of demonstrator and private practice took a lot of time, yet he managed a few hours every day for research. He and Prof. Trivedi published few papers during this time.

Prof. M.N. Dey was optimistic regarding his future and he also had a clear idea of the condition of medical research in this country. By heart and soul he wanted to send Shambhunath abroad for further research work. At last the chance came. Prof. M.N. Dey was promoted as head of the Department in Medicine of Calcutta Medical College. He had an earlier contact with Prof. C.R. Cameron of London University. Second World War was over; so he was able to convince his son-in-law to go to London for research work. Initially Shambhunath was not interested to go abroad, probably out of concern for his family members in his native village. But he ultimately decided to move to London for further research. There he started research work under Prof. C.R. Cameron on Hydrocephalus – a disease in which fluid accumulates in the brain. But luck did not favour Shambhunath. Every time he tried to infect model rats with this disease they died of lungs infection. That frustrated him to such an extent that he decided to come back midway of his research. But Prof. Cameron advised him to do research on lung disease on which he can readily prepare his model. He got success and was honoured with a Ph.D. degree from London University. During his research work at London University College Hospital Medical School he saw one research fellow working with cholera bacteria and became interested in that. After coming back to India in 1949 he joined in Nilratan Sircar Medical College, Kolkata and devoted his

total life on cholera research.

Cholera is one of the oldest epidemics in the world. Initially it was thought that the disease was caused by some unknown poisonous vapour coming out from sewage. John Snow was the first British doctor who discovered that cholera is a waterborne disease. Italian scientist Filippo Pacini first discovered that it is caused by bacteria. But most credit goes to the German physician Robert Koch. In 1883, Koch came to Kolkata with his team for cholera research. On 7 January 1884, Koch announced in a dispatch that he had successfully isolated the bacillus of cholera in pure culture. One month later he wrote again, stating that the bacillus was not straight like other bacilli, but "a little bent, like a comma." It was named *Vibrio cholerae*.

Filippo Pacini

Though the cholera bacterium was discovered in 1884, scientists were failing to find a proper antidote for it. Koch believed this was mainly because scientists working with cholera at that time were doing so in their own countries, which were free from cholera epidemic. On the contrary, no work on cholera was being done in India where it is widespread and often attacks in epidemic form.

De did not believe in Koch`s poison theory according to which the cholera bacterium produced an exotoxin that killed the victims. In fact it took 76 years to find out the nature of the toxin produced by *Vibrio cholerae*. It was Shambhunath De who successfully proved that the toxin produced by *Vibrio cholerae* was an enterotoxin (a cytotoxin specific for the cells of the intestinal mucosa). Not only that, he was the first scientist to develop a successful rabbit model for cholera. In the intestine of the rabbit he made a special type of loop, these loops are known as a ligated intestinal loop in medical term. Using such type of loops De proved that *Vibrio cholerae* produced one type of endotoxin which is responsible for the diarrhoea seen in cholera patients. He was also able to explain why cholera often led to dehydration . It was totally new finding and opened up a new direction in medical research.

Ligated intestinal loopEndotoxin produced in the intestine

But like many noble works it was also neglected initially. Shabhunath and his co-worker Dr. D.N. Chatterjee published the paper in the journal *Nature* in December 1958, entitled " Enterotoxicity of culture-filtrate of *Vibrio cholerae*", which has been termed as a classic by the English biochemist W.E. van Heyningen, professor emeritus, University of Oxford (1983). In 1961, he was honoured with D.Sc. from London University. The arrival of a new strain of cholera bacterium called "*Vibrio cholerae* biotype *El Tor*" and the death of Prof. C.R. Cameron in 1966, who was not only his teacher but also a constant source of inspiration, made De lose all interest in cholera research. Moreover he did not receive any recognition for his work, which made him frustrated. He took his retirement from Calcutta Medical College in 1973 at the age of 58. He could apply for an extension which was the usual practice at that time. Then there was chances for him to become principal even the Director of Heath Services, but he became mentally depressed. He took voluntary retirement from research and started a small pathological laboratory to keep him engaged with work.

Robert Koch

At last due honour came to him in 1978. The Nobel Foundation invited De to participate in the 43rd Nobel Symposium on Cholera and Related Diarrhoeas. Though the first letter did not reach to him in time, still he has managed to go there for his valuable speech. His unique techniques and new discovery got recognised throughout the world. It inspired him a lot. After coming back to India he desired to work with the new variety *El Tor* biotype. Bose Institute passed a special resolution to appoint him as an emeritus scientist at the Institute. He passed away on 15 April 1985.

There is no doubt that De's discovery of cholera toxin introduced a new paradigm in cholera research. A recent search done on 19 November 2009 in the PubMed database using the keyword "cholera toxin" yielded a phenomenal 11, 168 publications based the work of De. His work on cholera toxin has impinged on diverse areas such as cellular physiology, biochemistry and immunology. His work was clearly far ahead of his times. Nobel Laureate Prof. Joshua Lederberg has not hesitated to give him the credit for oral rehydration therapy of cholera. In his word , "De's clinical observations led him to the bold thought that dehydration was a sufficient cause of pathology of cholera, that the cholera toxin can kill 'merely' by stimulating the secretion of water into the bowel".

Prof. Joshua Lederberg had nominated De for the Nobel Prize more than once. Said Lederberg, "our appreciation of De must then extend beyond the humanitarian consequences of his discovery. . . he is also an examplar and inspiration for a boldness of challenge to the established wisdom, a style of thought that should be more aggressively taught by example as well as precept." Hope we will be able to rectify our mistakes by showing proper gratitude to this unsung personality in his birth centenary year.

Dhrubajyoti Chattopadhyay is Education Officer, North Bengal Science Centre, (National Council of Science Museums) Siliguri (West Bengal). Mainly engaged for popularization of Science and to inculcate scientific temperament among the students.

Ricinus communis (castor bean):
A multipurpose crop for the sustainable environment

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Introduction

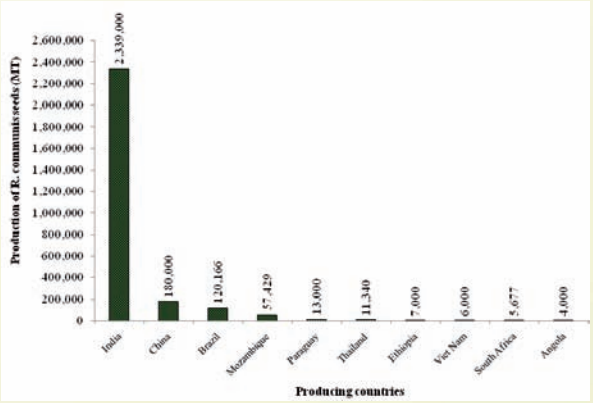
Ricinus communis L. (castor bean) is an oilseed crop belonging to family Euphorbiaceae, a monotypic genus *Ricinus*, and subtribe *Ricininae*, which includes some other significant energy plants as cassava (*Manihot esculenta*), rubber tree (*Hevea brasiliensis*) and physic nut (*Jatropha curcas*), etc. Among non-edible oils, castor oil is most popular for a wide variety of industrial, cosmetic and medical applications. Castor plant has been found worldwide, but it is cultivated mostly in tropical and sub-tropical countries like India, China, Brazil, USSR, Argentina, Thailand, Philippines, etc. In India, it is distributed throughout the warmer parts of the country and also can be found wild near habitation, roadside and on wastelands. One of the major attractions associated with castor is its easy cultivation, even in dry waste lands.

Scientific classification	
Kingdom	Plantae
Order	Malpighiales
Family	Euphorbiaceae
Subfamily	Acalyphoideae
Tribe	Acalypheae
Subtribe	Ricininae
Genus	*Ricinus* L.
Species	*R. communis*

Castor cultivated in field

Production of castor bean

Now-a-days castor bean is cultivated and also grows in the wild throughout the drier tropical, warm temperate and subtropical regions between 40° South and 52° North. The share of castor seed is less than 0.15% of total world trade of oil seeds. At present, the annual world production of castor seeds is more than 1.3 million tonnes, which corresponds to about 0.55 million tonnes of castor oil. Since the beginning of the 1970's, castor oil seed production has been increasing steadily. About half of all the castor oil produced in the world is exported, with India dominating the market with a share of almost 80%. According to the data of FAOSTAT (2011) India alone produces about 2,339,000 MT of castor oil seeds.



Top ten castor producing countries (Source: The Production Figures for 2011; FAOSTAT; http://faostat.fao.org/site/339/default.aspx).

Castor bean as an energy crop

In view of the rocketing oil prices, biodiesel is regarded as the best alternative to tackle the fuel crisis, reduce greenhouse gas emission as well as benefit agriculture. The cultivation of energy crops like *Jatropha curcas, Ricinus communis, Pongamia pinnata*, etc., adds an additional type of land use to the mix and provides an opportunity for restoring degraded land that have limited usefulness. Perennial energy crops like castor can be used for this sustainable approach. Such methods can simultaneously deliver other ecosystem services, for example, by enriching soil carbon and other nutrients and hence increasing soil fertility, providing protection against other biotic and abiotic factors like floods, wind erosion, etc.

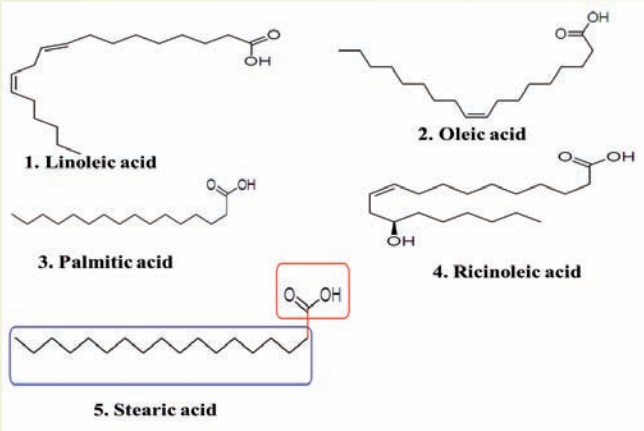
The seeds of castor are the source of castor oil, which has a wide variety of uses. The seed contains between 40% and 60% oil that is rich in triglycerides, mainly ricinolein. Castor oil is mostly used for a wide variety of industrial, cosmetic, medical and chemical applications. The presence of a high proportion of ricinoleic acid makes the oil suitable for the production of high-quality lubricants.

Restoration of degraded land with castor cultivation

Rehabilitation of vegetation is the most important among physical, chemical and biological methods for the restoration of degraded soils. Castor is not only an important oilseed crop but also has a significant tolerance to many stresses like heavy metals, salinity and drought, which make this plant capable of restoring such soils with some value-added benefits like biofuel production. Studies conducted have shown that after planting castor bean, soil quality is improved significantly. The activity and biodiversity of soil microbial communities along with other nutritional components also increased in the planted plots compared with that of the control. There were also similar increases in populations of halophilic, phosphate-solubilising, potassium-solubilising, cellulose-decomposing, ammonifying and nitrogen-fixing bacteria in the planted plots. Castor can be easily cultivated in waste lands and can provide an opportunity for the farmers to earn money by selling its seeds. Soil erosion is a major concern that is responsible for the degradation of agricultural lands throughout the world. Growing of deep-rooted shrubs like castor may help protect soil from erosion.

Remediation of contaminants by using castor

The remediation of contaminated soils, especially toxic heavy metal contaminated soil, is a very difficult task. However, some

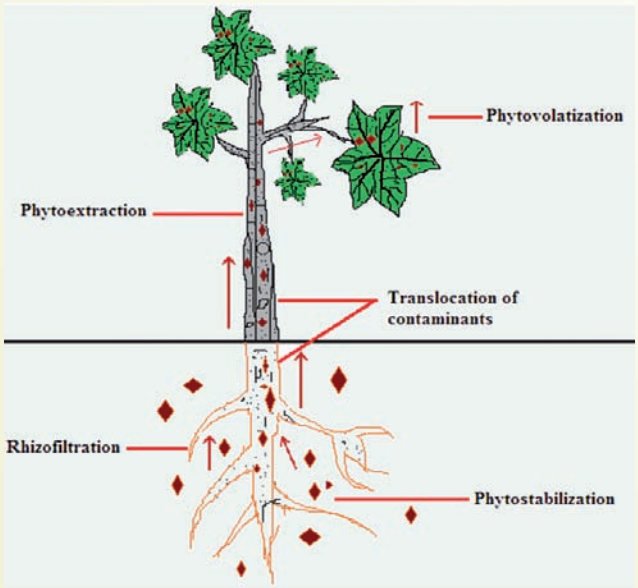


Fatty acid contents of oil of castor bean and their chemical structures

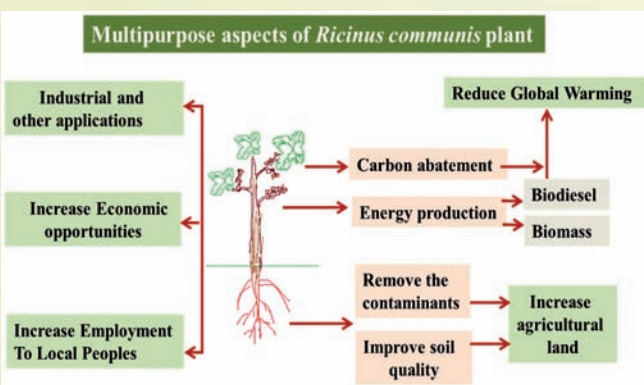
commonly used methods such as mechanical removal and chemical engineering are expensive, and are often incompatible with maintaining soil structure and fertility. Phytoremediation – the use of plant systems to remove the contaminants from the soils and water – has recently attracted a great deal of attention as an alternative means of soil decontamination, since it is a cost-effective, environmentally-friendly approach, applicable to large areas. Phytoremediation can be used to clean-up contaminants like metals, pesticides, solvents, explosives, crude oil, polyaromatic hydrocarbons and land-fill leachates. Phytoremediation is a very efficient method to remove heavy metals from soil and water.

The stages involved in phytoremediation include (i) phytoextraction (extraction of contaminants from the contaminated site and translocating them to aerial green parts of the plants); (ii) rhizofiltration (absorption and concentration of the contaminants in the roots and shoots of aquatic plants; (iii) phytostabilisation (plants immobilisation of the contaminants by plants to suppress the migration of contaminants to the soil or water); and (iv) phytovolatisation (absorption of some volatile toxicants from the contaminated sites by plants and their release into the atmosphere in a non-toxic or less toxic form).

In order to fully utilise the contaminated sites and to take advantage of phytoremediation, a new strategy of combining phytoremediation with oil crop cultivation, with a view to achieving low-cost decontamination of soil through the production of biodiesel is being recommended. Currently, castor is being popularised as a value-added plant for the phytoremediation of contaminated sites along with economic and ecological services. Because castor contains some peculiar features like unpalatability, high biomass productivity, tolerance to both biotic and abiotic stresses such as heavy metals, salinity, drought, pests and persistent organic pollutants, etc., it is ideally suited for the job.



General model for phytoremediation of contaminated soil/water



Castor bean is a perennial and oil-yielding crop can continue the removal of toxic metals as well as other contaminants throughout the year for a longer time within the same sowing which can reduce the operating and maintenance cost. Castor is a wild plant and has efficiency to produce high biomass without using any fertilizer. In addition, it is an industrially important plant with manifold non-food uses and has been considered as a cash companion crop.

Utilisation of industrial by-products

The production of oil from castor generates two main by-products, namely capsule husks, which is produced when the oil is extracted from the seeds. The production of one tonne of castor oil results in about 1.31 tonnes of husks and 1.13 tonnes of cake. It has been demonstrated through many scientific studies that the toxic protein ricin is destroyed by heat in the oil extraction process. Castor cake has about 43% protein content and is often used as an organic fertiliser as an excellent nitrogen source with insecticide and nematicide properties.

Other important applications

As a home remedy, castor oil is used widely for a number of problems and ailments. To name a few, castor oil helps deal with problems related to hair, skin, joints and intestine. Castor oil is also used for reducing inflammation and swelling of joints and tissues. The oil of castor and its derivatives have many applications in the manufacture of lubricants, soaps, hydraulic and brake fluids, paints and varnishes, cold-resistant plastics, waxes and polishes, pharmaceuticals and perfumes.

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Biomass: Renewable Source of Green Energy

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Before coal became popular in late mid-1800s, biomass supplied almost major demand of the world's energy and fuel. Then with availability of cheap petroleum, interest in biomass started diminishing. But with the sever crisis of the first oil shock in the mid-seventies, biomass was again back in the reckoning as a viable, domestic, energy resource that has the potential of reducing oil consumption and meet the energy demand to some extent. With increasing industrialisation, there is serious concern globally on the use of fossil fuels, the gap between energy demand and supply, and environmental issues arising from use of fossil fuels. Currently, the world is facing a grave energy crisis, which if unsolved will certainly have serious consequences for civilisation in the future. Along with other renewable energy sources like solar energy, wind energy, etc., biomass can play a vital role as an energy sourse, especially in rural areas. Biomass is organic matter from plants, animals and microorganism grown on land and in water and their derivatives. It can be obtained from agricultural field, forest crops, animal manure, urban and rural organic waste, industrial organic matter, aquatic biomass and a major part of household waste. Energy farm or energy plantation is a practice to grow quick-growing plant species for use as fuel at specific intervals. Biomass has advantages like abundant availability, ease of conversion to a high-energy fuel such as alcohol or gas, and ability to be grown in areas of unused agricultural land and provide jobs to rural communities.

Biomass can be utilised for various applications through different routes of conversion to produce heat and electricity, or used in combined heat and power (CHP) plants. In combination with fossil fuels (co-firing) it can be used to improve efficiency and reduce the generation of combustion residues.

Biomass energy in India

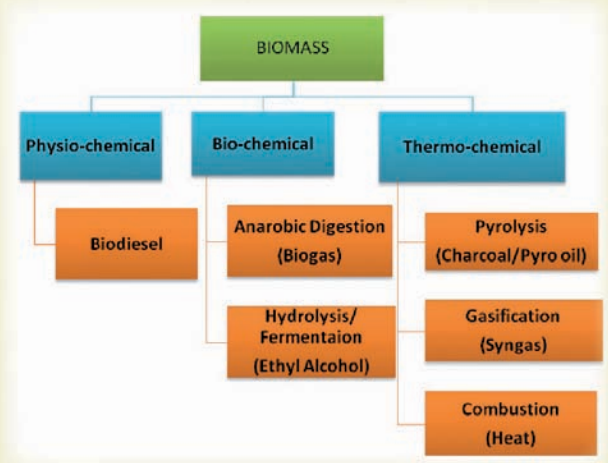
Biomass production in India is about 450-500 million tonnes/year. Biomass provides nearly 32% of all the primary energy use in the country at present and is the most important fuel used in over 90% of the rural households and about 15% of the urban households. It is estimated that the potential in the short term for power from biomass in India is about 18,000 MW. Biomass power plants in India are based mostly on agricultural waste as it is generated in abundance. Not all the biomass which is considered as agro-waste is usually a waste; but part of it is used as fuel for cooking, some part for cattle feed while some part is left to decompose in soil to retain the necessary soil nutrients. Probably, as per estimates, only two-thirds of agricultural residues could be used for power generation. Traditional use of biomass is more than its use in modern application

Biomass resources
(Courtesy: http://notocoal.weebly.com/greenergy.html)

Technologies for biomass conversion

Biomass is a feedstock with significant energy potential. Different technologies are available for energy recovery from biomass in different forms. Typically, conversion technologies for biomass can be either physical or chemical, or a combination of both. Physical conversion techniques are aimed at physically altering the biomass form. Chemical conversion techniques can be broadly classified on the basis of principles of conversion. Thermo-chemical conversion includes combustion, gasification, and pyrolysis, while biochemical methods include anaerobic digestion and fermentation. Biodiesel can be produced from oil seeds by the process of trans-esterification which later can used in blending with diesel. Each technology has its uniqueness to produce different forms of energy; for example, direct heat and secondary fuel in solid, gaseous or liquid form with some useful by-products.

Briquettes (compacted fine biomass) can be used directly in furnaces and boilers to replace coal in industry and in cookstoves for household applications. Biogas can be used for rural household application and electricity generation. Ethanol, product of fermentation, can be blended with petrol while biodiesel can be used in stationary or transportation diesel engines. Gas (syngas/producer gas) generated from gasification of biomass can be used for thermal and power application and can



Biomass conversion routes

Briquettes made from agricultural waste residues

replace the natural gas (100%) and diesel (up to 70%) in IC engines. Biodiesel produced from oil seeds can be used to replace diesel in internal combustion engine.

Biomass energy is reliable as it is free from fluctuations unlike wind power and does not need storage as in case of solar energy. Still, it has been a less-preferred renewable energy source till now; the main reason is the uncertain biomass supply chain. Collection and transportation itself is a big deal with fragmented land holdings. Biomass is available only after the harvesting

Biodiesel obtained from oil seed

period, which can stretch for 2-3 months in a year. For this stipulated time, it is necessary to procure and store required quantity of biomass. Lot of interest has developed in biomass energy in recent times, especially in applications like combined heat and power generation, and its significance as a clean source of heat for domestic heating and community heating applications. In fact, in countries like Finland, USA and Sweden the per capita biomass energy used is higher than that in India or China.

In India, The Ministry of New and Renewable Energy (MNRE) provides central financial assistance (CFA) in the form of capital subsidy and financial incentives to biomass energy projects. CFA allots the projects on the basis of installed capacity, energy generation mode and its application, etc. (More details can be accessed from the MNRE and state nodal agency websites.)

Obstacles

One of the most critical bottlenecks for biomass plants (based on any technology) is the supply chain bottlenecks that often results in non-availability of feedstock. A related problem is the volatility, or more precisely increase, in the feedstock price. Both these factors could affect the plant operation and project viability. For transportation fuels like biodiesel, large-scale cultivation of Jatropha or other oil seeds has been initiated. Likewise for ethanol production, the price and availability of molasses need to be stable. Long-distance transportation cost constitutes a significant portion of the costs associated with the establishment and running of biomass power plants.

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DD Bharati

निस्केयर NISCAIR

Vigyan Prasar & NISCAIR

jointly presents a new video serial

'Scientifically Yours'

(Serial on Eminent Women Scientists)

From 19 July, 2014, Every Saturday at 20:30-21.00 hrs

Vigyan Prasar in collaboration with CSIR-NISCAIR, has developed inspirational video series titled "Scientifically Yours" on Indian Women Scientists who have contributed significantly to Indian Science. The programme on Indian women scientists are unique one as this section of society has not been sufficiently covered in the country. This is a collective effort of the institutions to bring the women legend scientists on to the centre stage and highlight their achievements and contributions.

A Curtain Raiser of the 'Scientifically Yours' was screened in the presence of media persons along with other invited guests from scientific institutions and laboratories. The would help in creating role models for students and researchers especially for girl students and motivate them in pursuing careers in basic and applied sciences. The women scientists of eminence have been identified from various fields of research such as Physical sciences, Biological sciences, Chemical sciences, Immunology, Agriculture etc. 'Scientifically Yours' have been produced in discussion mode at CSIR–NISCAIR studio. For more detail please visit: www.vigyanprasar.gov.in

The Tower of Hanoi and the Icosian Game


Dr. C.K. Ghosh Poonam Trikha

Introduction

For hundreds of years, mathematical puzzles have entertained and enlightened our minds; they have also enabled mathematicians to make breakthroughs in the world of mathematics and science. They have been developed and used as important tools to educate people and explain a wide range of concepts. The puzzles 'Tower of Hanoi' and the 'Icosian Game'helparouse minds to learn crucial mathematical concepts.

The *Tower of Hanoi* (ToH) is an age-old mathematical game. It has a very interesting link with the 'Icosian Game' which became popular during the middle of 19th century. Here,we shall first use the game to present the 'Method of induction' (used particularly in algebra) in a very innovative way. Then, we shall discuss the link with the Icosian Game. First, let us talk briefly about the game, '*Tower of Hanoi*'.

Background

It is said that the '*Tower of Hanoi*' was invented by the French mathematician Edouard Lucas in 1883 and was sold as a toy. Originally it was called 'Prof. Claus' of the College of 'Li-Sou-Stian'. As a matter of fact the two names within the single inverted commas are the anagrams of 'Prof. Lucas' of the College of 'Saint Louis'.

The toy is depicted in Fig.1. It shows a rectangular base with three pegs. There are four circular disks fitted into one peg in the form of descending order of diameter from bottom to top. The problem is to transfer the four disks to any of the two vacant pegs in least possible number of moves. In each move only one disk can be moved and a larger disk cannot be placed over a smaller one.

It is not difficult to establish that the minimum number of moves irrespective of the number of disks is (2^n-1) where n is the total number of disks. Thus one disk can be shifted in 1 (=2^1-1) move, two disks in 3 (=2^2-1) moves, three disks in 7 (=2^3-1) moves, four disks in 15 (=2^4-1) moves. Fig. 2 depicts the fifteen moves for shifting four disks from one peg to another. Sixteen stages have been shown out of which the first one (top left) indicates the original position. The remaining fifteen are moves. One has to go serially down along the left column. In the first move, shifting of one disk gets accomplished. In the third move, as expected, shifting of three disks gets completed. Similarly as anticipated, shifting of three disks happen in seven moves;this is the last diagram in the left column.Then one has to come to the right column and come down below to the fifteenth move which indicates the completion of shifting of four disks. Five disks get shifted in 31 (=2^5-1) moves. For seven disks, the number of moves would be 127 (=2^7-1), whereas for eight disks the number would be 255 (=2^8-1).

Fig. 1. Tower of Hanoi

The original description of the toy is based on a temple called the '*Tower of Brahma*' in the city of Varanasi. The Tower is said to consist of 64 disks of gold. So the total number of moves would be 2^{64}-1, that is 18,446,744,073,551,615 which is a 20-digit number. If someone is asked to accomplish the task, and for the sake of argument let us presume that he is capable of shifting one disk in one second, then it would take him many thousands of millions of years to finish the job, which is much more than the predicted age of the universe.

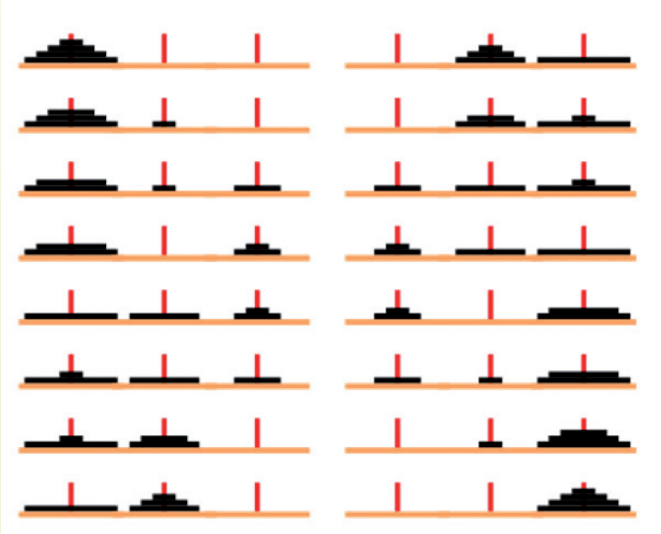

Fig. 2. Schematic diagram of the movements pertaining to the shifting of four disks

The number of moves corresponding to the number of disks which we had spelt out abovecan be obtained in the form of a logical sequence. We shall now present that and also show that the method of mathematical Induction can be illustrated very elegantly using the example of the *Tower of Hanoi*.

Mathematical Induction

Mathematical induction is a method of using inductive logic for mathematical derivations. It is essentially a method of mathematical proof typically used to establish that a given statement is true for all natural numbers (n).The idea is to show that the statement is true first for n = 1, then n = 2,3 and so on. It is presumed that statement is true for $n = m$ and based on that it is shown that it is also

true for $n = m + 1$. If this can be established, it means that if the statement is true for $n = 1$, it is true for $n = 1 + 1$, i.e. 2 again $n = 2 + 1$, i.e. 3 and thus for all natural numbers.

Let us illustrate this first by proving the statement that 'the sum of the first n natural numbers is equal to $\frac{1}{2} n (n + 1)$ or in other words,

$$S_n = 1 + 2 + 3 + \ldots + n \frac{1}{2} n (n + 1) \quad - (1)$$

Let us presume that (1) is true for $n = m$, which means

$$S_m = 1 + 2 + 3 + \ldots + m \ \frac{1}{2} m (m + 1)$$

Now,

$$S_{m+1} = S_m + (m + 1)$$

$$= \frac{1}{2} m (m + 1) + (m + 1)$$

$$= (m + 1) \ (\frac{m}{2} + 1)$$

$$= \frac{1}{2} (m + 1) + (m + 2)$$

$$= \frac{1}{2} (m + 1) \{ (m + 1) + 1\}$$

So the result is also true for $n = m + 1$.

Now, let us look for the sequence of moves of the disks of the *Tower of Hanoi*.

Let us name the discs *a, b, c, d, e, f, g*, ... when $n = 1$, we have 1(one) move, i.e., '*a*' when n = 2, we first move *a*, say counterclockwise,then we move *b* clockwise and place it on a blank stick, then we move *a* again counterclockwise and place it over *b*. Thus in 3 (three) moves, the two-disk tower gets shifted from one position to another. The three moves can be recorded as (*aba*).

Basically, it may be observed that we have applied the method of induction. The disc *a* has been moved in the same manner as was done in case of $n = 1$. In between, during the second move, *b* was shifted. We shall understand the method of induction better with $n = 3$.

The third disk is *c*. It would be moved only once to the location where the tower is to be shifted. It would be the central move flanked by the moves pertaining to $n = 2$, before and after. So the sequence will read *abacaba*.It can be seen that (*aba*) has been placed on either side of *c*. The total count is 3+1+3 = 7, which is what we expect for n =3. Again for n = 4, we have to move the fourth disk *d* once to the location where the tower is to be shifted. It would be the central move flanked by the moves pertaining to $n = 3$, before and after. So the sequence will read *a b a c a b a d a b a c a b a*. We have placed (*a b a c a b a*) on either side of *d*. The total count is 7 + 1 + 7 = 15, which is what we expect for n = 4.

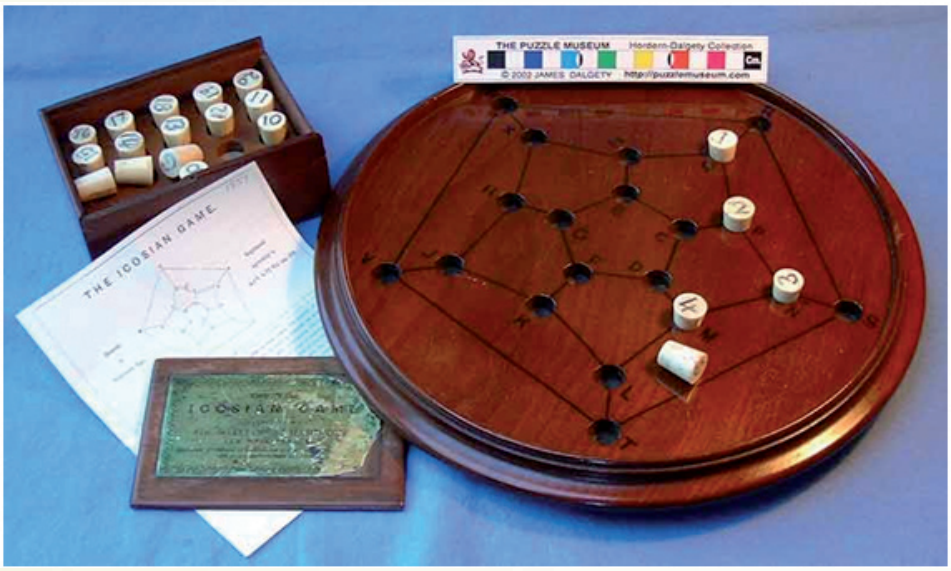

Fig. 3. Icosian Game on wooden board

Again the total count for *a b a c a b a d a b a c a b a e a b a c a b a d a b a c a b a* is 15 + 1 + 15 = 31, where *e* appears at the centre flanked by the sequence corresponding to n = 4 on either side of it. One has to remember that the crux of the movements is that the alternate disks would be moving respectively in counterclockwise and clockwise manners. In other words, if *a* moves first, say in the counterclockwise sense, then a, c, e, g, ... would always move in the counterclockwise sense and *b, d, f,* ... would always move in the clockwise sense.

Thus one aspect of mathematical induction gets reflected from the sequences and the manner in which the respective sequences for $n = 2, 3, 4, 5$... evolve from $n = 1, 2, 3, 4$... The other aspect is the derivation of the result for the number of required moves, which is $2^n - 1$.

As in the case of the proof for the sum of first n natural numbers, we presume that the result is valid for $n = k$, say. So we need to prove that the result in also valid for $n = k + 1$.

We find that while moving from $n = k$ to $n = k + 1$, we express the number of moves as

$$(2^k - 1) + 1 + (2^k - 1)$$

$$= 2 \times 2^k - 1 + 1 - 1$$

$$= 2^{k+1} - 1$$

So, the result is also valid for $n = k + 1$ which establishes the truth behind the fact that required number of moves for n disks is $2^n - 1$.

Thus we see that the game of *Tower of Hanoi* provides us with a very elegant method of understanding the method of mathematical induction.

Another puzzle that had historical influence on the world of mathematics is the '*Icosian Game*' puzzle (also known as the 'Hamilton Game'), which was designed by Sir William Rowan Hamilton in 1857. Hamilton was a famous Irish mathematician, physicist and astronomer who made many important contributions to classical mechanics and algebra.

The *Icosian Game*requires a player to plot a route, based on certain conditions, among the vertices of a dodecahedron. Here, we present a picture of an original version of the game on wooden board (Fig 3).

The motivation for Hamilton was the problem of symmetries of an icosahedron, for which he invented *icosians*—an algebraic tool to compute the symmetries. The solution of the puzzle consists of a cycle containing twenty (in ancient Greek *icosa*) edges (i.e. a Hamiltonian circuit on the dodecahedron).

The game's object is to finda Hamiltonian cycle along the edges of a dodecahedron such that every vertex is visited a single time, no edge is visited twice and the ending point is the same as the starting point.

In the mathematical field of graph theory, a Hamiltonian path (or traceable path) is a unidirectional path or a directed graph that visits each vertex exactly once.

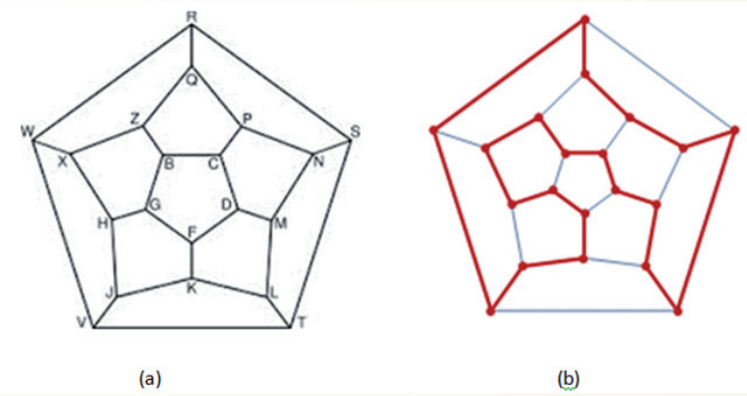

Fig. 4. (a) Hamiltonian tour (b) Hamiltonian path

A Hamiltonian cycle (or Hamiltonian circuit) is a Hamiltonian path,whichis a cycle.

In geometry, a dodecahedron is any polyhedron with twelve flat faces, but usually it means a regular dodecahedron: a Platonic solid. It is composed of 12 regular pentagonal faces, with three meetings at each vertex. A graph having a Hamiltonian cycle, i.e., on which the Icosian Game may be played, is said to be a Hamiltonian graph.

The puzzle was distributed commercially as a pegboard with holes at the nodes of the dodecahedral graph. One can start at any corner on the solid (Hamilton labelled each corner with the name of a '*large city*); then by travelling along the edges tomake a complete '*trip around the world*', visiting each vertex once and only once, and return to the starting corner. In other words, the path must be a closed circuit along the edges, passing through each vertex. In the following diagram (Fig. 4), the first image (a) shown is a tour and the second (b) is a path. This puzzle has 20 solutions, one of which shown in the figure.

One can now try out the following puzzle (Fig. 5). A path from A to Z has to be plotted, landing on each of the other squares once — and only once. One can move from one square to another if the squares are adjacent or if they are connected by a blackened path. (A path at the edge of the diagram wraps around to the opposite edge.) To plot the route, one can draw a line or label the squares along the way with the letters from A to Z. One can draw on paper so that one can try out different routes. Each puzzlehas a solution and if one staysoncourse and works through the clues,one will arrive at the answer.

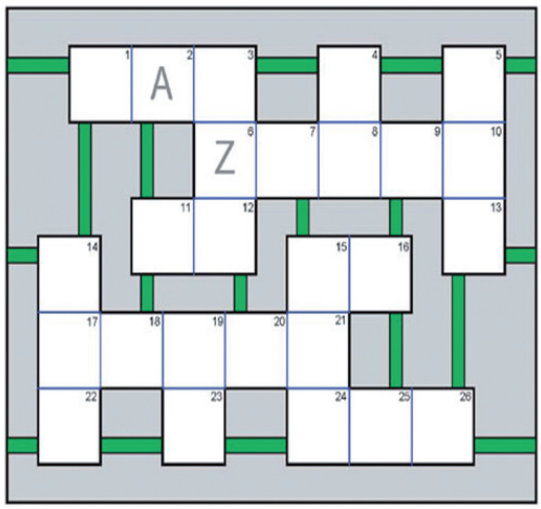

Fig. 5. Another form of Icosian Game

Now, the question is - how is *Tower of Hanoi* puzzle related to Hamilton's *Icosian Game*? For this let us first consider *Tower of Hanoi* puzzle with three disks only, labelling the disks from top to bottom, *A*,*B* and*C*. If the procedure given in *Tower of Hanoi* puzzle is followed,one can solve the puzzle by moving the disks in the order:*ABACABA*. Now, let us label the three coordinates of a regular hexahedron, commonly called a cube, as shown in Fig. 6 with *A*, *B* and *C*.

If one traces a path along the edges

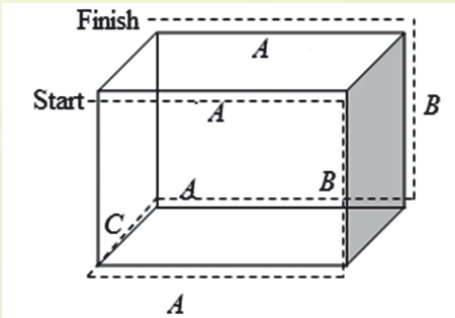

Fig 6. Linking 'Tower of Hanoi' with the 'Icosian Game'

of the cube, choosing the coordinates in the order *ABACABA*, the path will create a Hamiltonian circuit. It is to be appreciated that there is a remarkable similarity between the orders of transferring *n* disks in '*Tower of Hanoi*' puzzle to the order of coordinates in tracing a Hamiltonian path on a cube of *n* dimensions. They are exactly the same.

In the similar way, when the '*Tower of Hanoi*'puzzle is solved with four disks, the order of transferring disks is *ABACABADABACABA*, it corresponds to the '*Traverse the Hypercube*' model(a four-dimensional cube) for Hamiltonian circuit. By following the same procedure, five disks transfer in an order corresponding to a Hamiltonian circuit on a five-dimensional hypercube, and so on.

We know that nature loves symmetry. Similarly mathematical logic which plays very significant role in governing the nature also follows symmetry and unity of thought. The link between the '*Tower of Hanoi*' puzzle and the '*Icosian Game*' is a testimony to that. So theyare indeed a puzzle and a game but is much above them as they are reflective of very significant feature of unity of mathematical understanding.

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Corrigendum

Leo Szilard

1) In the article "Seventy-five Years of Nuclear Fission" (Dream 2047 July 2014) by M.S.S. Murthy, the picture of Leo Szilard on page 30 was printed wrongly due to technical error. The correct picture is given here.

2) In the article "Conservation of wetlands and waterbirds" on page 28 the second author name is S. Ramanathan instead of S. Kannan. The errors are regretted.

Mystery behind the GloFish:
the genetically modified fish that glow!

"Homo sapiens have progressed leaps and bounds from hunting and gathering to culturing to engineering!!!"

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After bringing forth marvels in the field of agriculture, livestock and medicine, bio-engineering has spread its golden touch to the entertainment industry as well! Glowing animals have been produced to delight the aesthetic instinct of pet lovers.

The glowing fishes are genetically engineered, vibrantly flourescent genetically modified fish that embellish the aquaria and captivate the beholder. Though originally not produced for ornamentation, these genetically modified organisms (GMOs) were an instant hit with aquarium lovers the moment they were introduced into the ornamental fish industry. These fluorescent aquatic angels are marketed under the brand names GloFish and TK-1.

Initially, the GloFish referred to a patented brand of genetically modified version of zebra fish, *Danio rerio*, the first GMO to be made publically available as a pet. The original zebra fish from which the GloFish was developed is indigenous to Indo-gangetic rivers. Measuring around three centimetres, the zebra danio is a very agile fish adorned with golden and blue stripes that further enhance the beauty of an aquarium. Over 200 million of these living jewels have been sold in the last fifty years in the US ornamental fish market. While *Danio rerio is* sold at the rate of Rs.6 in local markets, its value overseas is US $0.16/ pair.

The florescent version of *Danio rerio* was created with an objective to develop a pollution indicator that could selectively fluoresce in presence of environmental toxins. The development of a permanently fluorescing fish was meant to be the first step in this direction. For this, scientists from the National University of Singapore extracted a gene encoding green fluorescent protein (GFP) responsible for bioluminescence in a jelly fish. The gene when inserted into an embryo of zebra fish, integrated with its genome. Thus, these glowing beauties came into being! Later, red and orange-yellow florescent zebra fish were developed by adding genes from sea coral and a variant gene of jellyfish respectively. Soon, an American company in Texas, USA, obtained the worldwide rights to market these GMOs under the brand name 'GloFish'.

The original zebrafish, Danio rerio

The popularity of these glowing pets led to creation of fluorescent versions of other fish varieties such as tiger barbs (*Puntius tetrazona*) and tetras (*Gymnocorymbus temetzi*). The GloFish are now available in

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Some facts about the GFP

The light-emitting molecule of fireflies 'luciferin' glows when oxidised by enzyme 'luciferase' in presence of magnesium ions and ATP. GFP, on the other hand, needs nothing but blue light along with a bit of oxygen to glow. GFP was first used by Martin Chalfie, a biologist at Columbia University, USA, and his colleagues in 1994 in *E. coli* and *Caenorhabditis elegans*.

Uses of GFP:

- The alteration in the zebra fish's genes has given the organism the ability to fluoresce as a bio-indicator. This genetic ability has been used to detect pollution and other chemicals.
- It has been used to detect genetic mutations in nematodes.
- GFP-insulin fusion proteins are used to visualise insulin secretion.
- It is also used to study sequence of gene expression in developing zebra fish.
- GFP-labelled bacteria are used to investigate how much chlorine it takes to kill bacteria in drinking water.

Variants of GFP have now been discovered that glow more brightly, are more stable or emit different coloured light.

Hair loss

Causes and Remedies

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The yearning for long and beautiful hair cuts across gender and fairytales. Still, growing hair and maintaining them is no simple task. The human scalp has about 100,000 strands of hair. Each hair arises from a follicle, which lies beneath the skin surface. Its expanded end is called the bulb, wherefrom the hair shaft grows.

Each hair shaft grows at a set pace. Those on the human scalp grow about 0.35 mm a day. Or roughly, half-an-inch (about 13 mm) per month! This growth, however, is not nonstop. After growing for two to six years, the scalp hair generally go into a resting phase. At this time, they tend to fall while being combed or washed. Happily, only about 10 per cent of the scalp hair enter the resting phase at a time. This period of rest lasts only a few months. Soon the hair begins to grow again.

In some people, the growing phase just goes on and on, extending to as long as 25 years or more! The secret of their long and beautiful hair lies therein. If you are blessed thus, you have only Mother Nature to thank.

Many people worry about hair loss unnecessarily. To lose hair is natural. Each time you comb your hair, some twenty, thirty, forty or more strands fall out. Most people normally shed 50 to 100 hairs a day. This is the way of Mother Nature. After a couple of months, new 'hair' appear. This cycle of hair loss and replacement go hand in hand. As long as the replacement keeps pace with the loss, the pate stays covered!

Sometimes, however, people suffer an abnormal hair loss. Hair loss – call it *alopecia*, if you will – can affect just your scalp or your entire body. It can be the result of heredity, certain medications or an underlying medical condition. Anyone – men, women and children – can experience hair loss.

Baldness typically refers to excessive hair loss from your scalp. Some people prefer to let their baldness run its course untreated and unhidden. Others may cover it up with hairstyles, makeup, hats or scarves. And still others choose one of the medications or surgical procedures that are available to treat hair loss. Before pursuing any treatment option, talk with your doctor about the cause of and best possible treatments for your particular type of hair loss.

Patterns of hair loss

Hair loss can appear in many different ways, depending on the problem that's causing it. It can come on suddenly or gradually and affect just your scalp or your whole body. Some types of hair loss are temporary, while others are permanent. Signs and symptoms of hair loss may include:

Gradual thinning on top of head

This is the most common type of hair loss, affecting both men and women. In men, hair often begins to recede from the forehead in a line that resembles the letter M. Women typically retain a line of hair at the forehead but experience a broadening of the part in their hair.

Circular or patchy bald spots

Some people experience smooth bald spots, often about an inch (2.6 centimetres) across. This type of hair loss usually affects just the scalp, but it sometimes also occurs in beards or eyebrows. In some cases, your skin may become itchy or painful before the hair falls out.

Sudden loosening of hair

A physical or emotional shock can cause hair to loosen. Handfuls of hair may come out when combing or washing your hair or even after gentle tugging. This type of hair loss usually causes overall hair thinning and not bald patches.

Full-body hair loss

Some conditions and medical treatments, such as chemotherapy for cancer, can result in the loss of hair all over your body. The hair usually grows back after treatment ends.

Causes of hair loss

Most people normally shed 50 to 100 hairs a day. But with about 100,000 hairs in the scalp, this amount of hair loss shouldn't cause noticeable thinning of the scalp hair. As people age, hair tends to gradually thin. Other causes of hair loss include hormonal factors, medical conditions, medications, stress and strains, and certain hairstyles.

Hormonal factors

In Men : The most common cause of hair loss is a hereditary condition called male-pattern baldness or female-pattern baldness. In genetically susceptible people, certain sex hormones trigger a particular pattern of permanent hair loss. Most common in men, this type of hair thinning can begin as early as puberty.

In Women : Hormonal changes and imbalances can also cause temporary hair loss. This could be due to:

- Pregnancy
- Childbirth
- Discontinuation of birth control pills or
- the onset of menopause

Medical conditions

A variety of medical conditions can cause hair loss. These include the following:

Thyroid problems : The thyroid gland helps regulate hormone levels in your body. If the gland isn't working properly, hair loss may result.

Alopecia areata : This disease occurs when the body's immune system attacks hair follicles – causing smooth, roundish patches of hair loss.

Scalp infections : Infections, such as ringworm, can invade the hair and skin of your scalp, leading to hair loss. Once infections are treated, hair generally grows back.

Skin disorders : Some skin disorders that can cause scarring, such as lichen planus and some types of lupus, can result in permanent hair loss where the scars occur.

Medications

Hair loss can be caused by drugs used to treat:

- Cancer
- Arthritis
- Depression
- Heart problems
- High blood pressure

Physical stress

Many people experience a general thinning of hair several months after a physical illness or stress. Examples include high fever, sudden or excessive weight loss, or following a surgery.

Emotional shock

A sudden emotional crisis or shock, such as a death in the family, can precipitate acute hair loss two to three months later.

Hair-pulling disorder

This mental illness causes people to have an irresistible urge to pull out their hair, whether it's from the scalp, their eyebrows or other areas of the body. Hair pulling from the scalp often leaves patchy bald spots on the head.

Certain hairstyles

Traction hair loss can occur if the hair is pulled too tightly into fashionable hairstyles.

Factors which make you vulnerable

Family history

Your risk of hair loss increases if relatives on either side of your family have experienced hair loss. Heredity also affects the age at which you begin to lose hair and the developmental speed, pattern and extent of your baldness.

Hair treatments

Overuse or improper use of hair-colouring products, hair straighteners and permanent waves can leave your hair brittle and prone to breaking off at the scalp. Excessive hairstyling or hairstyles that pull your hair too tightly cause traction alopecia.

Poor nutrition

Your hair may thin out if you skimp on good dietary sources of iron and protein. Hair loss related to poor nutrition often accompanies eating disorders and crash dieting.

Prevention the best key

These tips may help you avoid preventable types of hair loss:

- Eat a nutritionally balanced diet.
- Avoid tight hairstyles, such as braids, buns or ponytails.
- Avoid compulsively twisting, rubbing or pulling your hair.

When to see a doctor

Talk to your doctor if you notice sudden or patchy hair loss or more than usual hair loss when combing or washing your hair. Sudden hair loss can signal an underlying medical condition and may require medical treatment.

You're likely to first bring your concerns to the attention of your family doctor. He or she may refer you to a dermatologist – a doctor who specialises in the treatment of skin problems.

What to expect from your doctor

Your doctor is likely to ask you a number of questions. A complete medical history, family history and physical examination can help in a diagnosis. The pattern and rate of hair loss, the appearance of nearby hairs, and accompanying symptoms are considered when making the diagnosis.

Lab tests

Your doctor may perform blood tests to determine if you have a medical condition that causes hair loss, such as thyroid disease, diabetes or lupus.

Biopsies and samples

During a pull test, several dozen hairs are gently pulled to see how many come out. This helps determine the stage of the shedding process.

Scraping samples

Scraping samples taken from the skin or from a few hairs plucked from the scalp can help verify whether an infection is causing hair loss.

Punch biopsy

When a diagnosis is difficult to confirm, your doctor may perform a punch biopsy. During this test, the doctor uses a circular tool to remove a small section of your skin's deeper layers.

Remedies and treatments

For some types of hair loss, hair may resume growth without any treatment. In other situations, treatments may help promote hair growth or hide hair loss.

Medication

If your hair loss is caused by an underlying disease, treatment for that disease will be necessary. This may include drugs to reduce inflammation and suppress your immune system, such as prednisone. Medications to treat hair loss include:

Minoxidil : Minoxidil is an over-the-counter liquid or foam that you rub into your scalp twice daily to grow hair and to prevent further loss. Some people experience some hair regrowth or a slower rate of hair loss or both. It may take 12 weeks for new hair to start growing. Minoxidil is available in a 2 percent solution and in a 5 percent solution. Side effects can include scalp irritation and occasionally unwanted hair growth on the adjacent skin of the forehead or face.

Finasteride : This prescription medication to treat male-pattern baldness is taken daily in pill form. Many men taking finasteride experience a slowing of hair loss, and some may show some new hair growth. Rare side effects of finasteride include diminished sex drive and sexual function. The FDA has also warned that in some men there's an increased risk, though low, of getting a fast-growing type of prostate cancer. Finasteride should be avoided by women of childbearing age.

Surgery

In the most common type of permanent hair loss, only the top of the head is affected. Surgical procedures can make the most of the hair you are left with.

Hair transplants : This type of procedure removes tiny plugs of skin, each containing a few hairs, from the back or sides of your scalp. The plugs are then implanted into the bald sections of your scalp. Several transplant sessions may be needed, as hereditary hair loss progresses with time.

Scalp reduction : This procedure surgically removes some of the bald skin on your head. After hairless scalp is removed, the space is closed with hair-covered scalp. Doctors can also fold hair-bearing skin over an area of bald skin in a scalp reduction technique called a flap.

Surgical procedures to treat baldness are expensive and can be painful. Possible risks include infection and scarring.

Wigs, hairpieces and hair-weaving

If you would like an alternative to medical treatment for your baldness or if you don't respond to treatment, you may want to consider wearing a wig or hairpiece. They can be used to cover either permanent or temporary hair loss. Quality, natural-looking wigs and hairpieces are available. You may also consider going in for hair-weaving, a more expensive alternative.

Continued from page 25 **(Mystery behind the GloFish)**

six striking colours: Starfire red, Cosmic blue, Electric green, Galactic purple, Sunburst orange, and Moonrise pink.

While the GloFish was patented by York Technologies, Texas, a florescent green medaka (rice fish, *Oryzias latipes*) was produced by a team of researchers at the National University of Taiwan and patented under the name TK-1. One hundred thousand of Tk-1 was reported sold in less than a month at US$ 18.60 per piece!

Initially, the GFP coding gene was obtained from jellyfishes. Gradually, other Coelenterates were also tapped for fluorescent protein producing genes. They include *Aequorea victoria* (jellyfish), *Renilla reniformis* (sea pansy), *Discosoma* (mushroom coral), *Entacmaea quadricolor* (sea anemone), *Montipora efflorescens* (stony coral), chalice coral, *Anemonia sulcata* (Venus hair anemone), *Lobophyllia hemprichii* (open brain coral), and *Dendronephthya* (octocoral).

Apart from beautifying aquaria, frozen and raw GloFish are used to make a visually exciting addition to experimental sushi and other recipes in some states of US!

Dr Alpana Vohra is an Assistant Professor in Zoology who specializes in ornamental fishes

Recent developments in science and technology

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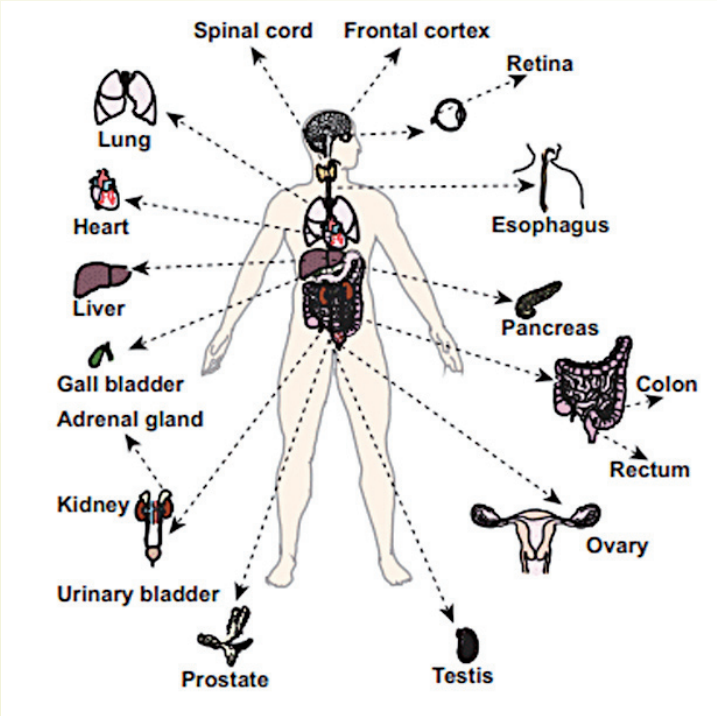
Human proteome mapped

In genetics, proteome is the entire complement of proteins that is or can be expressed by a cell, tissue, or organism, just as genome describes the full complement of genes of an organism. The proteome is an important complement to the genome and transcriptome, the latter representing a small percentage of the genetic code that is transcribed into RNA molecules. Together they create a more complete resource for research in health and diseases. While genes determine many of our characteristics, they are able to do that by providing instructions for making proteins, which play a vital role in health and disease.

It was more than a decade ago when scientists published the draft human genome sequence – an inventory of all the genes in humans – under the Human Genome Project. However, an equivalent map for the human "proteome" with direct measurements of proteins and peptides did not exist so far. Now, two international teams have independently produced the first drafts of the human proteome. Working separately, a 72-member team from the Institute of Bioinformatics (IOB) in Bangalore, India, and Johns Hopkins University, Baltimore, USA, and another team from Technische Universitaet Muenchen, Munich, Germany have not only produced a draft map of the human proteome, but have also published their results the same day in the same journal (*Nature*, 29 May 2014 | doi:10.1038/nature13302, 2014 and doi:10.1038/nature13319, 2014).

Both research teams took advantage of mass spectrometry, which has revolutionised the study of proteomics (the branch of genetics that studies the full set of proteins encoded by a genome) in a manner similar to the impact of the most advanced gene sequencing techniques on genomics. In addition, both teams compiled information about the types, distribution, and abundance of proteins in various cells and tissues.

For example, the Bangalore/Baltimore team conducted in-depth profiling of 30 normal human samples, including 17 adult tissues, seven foetal tissues, and six purified primary hematopoietic (blood-forming) cells. The Bangalore/Baltimore team identified proteins encoded by 17,294 genes, which is about 84% of all the genes in the human genome predicted to encode proteins. The Munich team is reported to have catalogued over 18,000 proteins.



The 17 adult tissues used in mapping of the human proteome. In addition, seven foetal tissues were also used. (Credit: Nature)

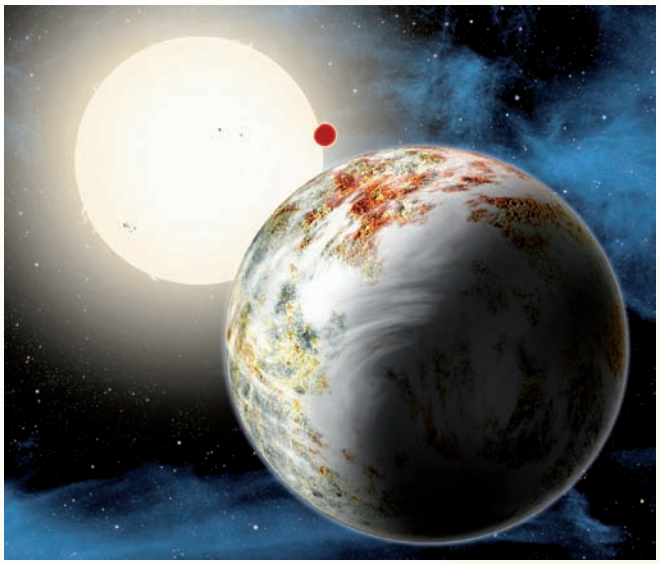
The Bangalore/Baltimore team reported that it had identified 193 novel proteins that were coded by regions of the genome not predicted to code for proteins, suggesting that the human genome is more complex than previously thought. Similarly, the Munich team had discovered "hundreds of protein fragments that are encoded by DNA outside of currently known genes." These new proteins may possess novel biological properties and functions.

According to team member Akhilesh Pandey, currently a professor at the Johns Hopkins University and founder director of IOB, Bangalore, "The fact that 193 of the proteins came from DNA sequences predicted to be non-coding means that we don't fully understand how cells read DNA, because clearly those sequences do code for proteins,"

While the mapping of the human proteome may not prove to be as revolutionary as the formulation of calculus by Newton and Leibniz, or Darwin's theory of evolution, it is still an important breakthrough. By comprehensively cataloguing human proteins, the Bangalore/Baltimore team and the Munich team together have created a resource for other researchers that promises to advance personalised medicine (a medical model that proposes the customisation of healthcare using molecular analysis). While the draft map cannot fully capture the complexity of the human proteome, nonetheless it provides a solid foundation that others can reliably build upon. For example, the draft map could offer deeper insight into why humans suffer from conditions like diabetes, cancer, thalassemia, heart problems, and other diseases.

Kepler discovers a 'mega-Earth'

Planets can be sorted, very roughly, into two categories: gas giants and terrestrial planets. Gas giants (like Jupiter, Saturn, Uranus, and Neptune) are made up of mostly gases and have huge, thick atmospheres of hydrogen, helium, and other gases, while terrestrial planets (like Mercury, Venus, Earth, and Mars) are composed mostly of rock and metals, and some with a thin atmosphere. The largest planet of our Solar System, Jupiter has a diameter 11.2 times that of Earth and



An artist's impression of the newly classified "mega-Earth" Kepler-10c (foreground). The second planet, Kepler-10b is in the background. Kepler-10c is made up of solids, although it may possess a thin atmosphere shown here as wispy clouds. (Credit: David A. Aguilar)

a mass 318 times that of our planet. But Jupiter is a gaseous planet; it has no rocky surface like Earth and so no possibility of supporting life. Recently, astronomers have announced that have found a new type of exoplanet: a rocky world much larger than Earth that may have a thin envelope of an atmosphere, making its surface cool enough to support life. Orbiting a star 564 light-years away in the constellation of Draco, the new rocky planet named Kepler-10c circles its 11-billion-year-old, Sun-like star once every 45 days. It shares the star system with another planet, Kepler-10b, which is three times the size of Earth and orbits the star in only 20 hours.

What is most astonishing about Kepler-10c is its mass. The heavy-set planet is 2.3 times the size of Earth, but has a mass about 17 times as much as our planet. This means that Kepler-10c is not a gas giant like Jupiter, but is likely made of rock and other dense solids and maybe 5-15% of water – something astronomers had thought was impossible for a planet of this size. The findings were announced at the meeting of American Astronomical Society in Boston, USA on 2 June 2014.

Kepler-10c was one of the first exoplanets discovered by the *Kepler* space telescope – the robotic space mission that has been searching for planets beyond our solar system since 2009. When first discovered by the *Kepler* space probe in 2011, Kepler-10c's diameter was measured at 2.3 times that of Earth (29,000 km), which led scientist to think that it was a "mini-Neptune" with a structure similar to that of the gas giants of the Solar System. But until now, they did not realise how massive it was. Recently, using the *Kepler* data as the starting point, astronomers at the Harvard-Smithsonian Center for Astrophysics led by astronomer Xavier Dumusque looked at Kepler-10c with the HARPS-North instrument on the Telescopio Nazionale Galileo in the Canary Islands. They were finally able to find out the planet's mass; it was far more than they had expected. This indicated that Kepler-10c must have a dense composition of rocks and other solids.

According to astronomers, the discovery of Kepler-10c would require scientists to rethink ideas on planet formation and the likelihood of life in our galaxy. It is believed that the early universe contained only hydrogen and helium; heavier elements needed to make rocky planets, like silicon and iron, were created in the first generations of stars. When those stars exploded, they scattered these crucial ingredients through space, which then could be incorporated into later generations of stars and planets – a process that would have taken billions of years. However, Kepler-10c shows that the universe was able to form dense rocks even during the time when heavy elements were scarce.

The researchers point out that the Kepler-10 star system is 11 billion years old, which means it was formed only about 3 billion years after the Big Bang. The presence Kepler-10c with its rocky structure indicates that the heavy elements needed to make such a planet were available earlier than thought. If this is the case, then, the researchers say, there may be habitable planets that may be very old, which increases the chances of life being found elsewhere in the universe.

Ants smarter than Google?

It is common knowledge that ants have uncanny ways of finding food be it a drop of sugar syrup, breadcrumbs, or even a dead cockroach. It does not matter if they are on the ground or inside the farthest kitchen cabinet; ants have an amazing way of finding things out. Once found, hundreds of ants would gather around the object within minutes and often carry it to their nest. How do ants come to know about a food item lying somewhere in so short a time and how do they pass on the information to their community?

An individual ant's movements appear chaotic; they seem to move aimlessly. But once an ant finds food, it quickly returns to its nest to inform the others about the discovery. Scientists have known that ants smell their way to their food source and leave chemical signals known as pheromones for other ants to trace back to the food source. However, pheromones evaporate quickly, yet in a short time a wave of ants trace the path back to the source to retrieve it; from the chaotic movement of a single ant it becomes an organised mass movement. Over time, the ants organise their search, optimising the best and shortest path between the food and the nest.

Ants use their intelligence and experience to locate food and carry it to their nest. (Credit: Biman Basu)

As more ants follow the optimal path back and forth, they leave more and more pheromones, which in turn attract more and more ants, creating a self-reinforcing efficiency effect. The chaotic, seemingly random foraging of individual ants is replaced by organised precision. The whole process is quite complex and recent studies by researchers of the Potsdam Institute of Climate Research, Germany, on the foraging behaviour of ants shows just how smart ants really are. In order to better understand the collective foraging behaviour of ants, scientists collected everything they knew about the insect and converted it into equations and algorithms and fed this data into their computers. According to the researchers, "working as one, ants create the sort of distribution networks a traffic engineer could only dream of. The older and wiser ants have a better understanding of their environment than the younger interns". While the single ant is certainly not smart, the collective acts in a way that can be certainly described as 'intelligent'.

In a comprehensive mathematical study the researchers found that the transition from chaotic to organised regimes results from an optimisation scheme of the self-organisation of an ant colony. They found that effective foraging of ants mainly depends on their nest as well as their physical abilities and knowledge due to experience. "As an important outcome, the foraging behaviour of ants is not represented by random, but rather by deterministic walks, in a random environment: Ants use their intelligence and experience to navigate" (*Proceedings of National Academy of Sciences*, 27 May 2014 | doi:10.1073/pnas.1407083111).

The researchers also made an interesting discovery. They found that individual ants differ in their ability to find food. Over time, older ants gather more experience about the environment surrounding their nests, which makes it easier for them to forage effectively. The young ants are more like interns – their lack of experience means they cannot contribute much to foraging, but they are effectively learning on the job.

The study shows that the ant's search capabilities are good enough to rival our best technology, at least. For example, Google's search engine forages for information on the Web in much the same way an ant colony looks for food. Google's search algorithms use hundreds of signals to find the most efficient and accurate answer to any search query. In a similar manner, the ant colony quickly organises itself to find the most efficient path to a food source once it has been discovered by scouts. According to the researchers, "These insects are, without doubt, more efficient than Google in processing information about their surroundings".

Fistfights might have shaped the human face

Fistfight is the commonest form of fighting among humans, if we leave aside the use of weapons. New research suggests that fistfights may have contributed significantly to the evolution of a more bulky human face with bones tough enough to withstand a punching. In fact, the present shape of the human face is probably the outcome of millions of years of such violence.

Stronger facial bones appeared in the australopiths at about the same time as shifting hand proportions enabled our ancestors to clench their fists. (Credit: University of Utah)

Modern humans are characterised by both bipedality (walking on two legs) and a large brain, but the earliest members of our family lacked large brains. These were the australopiths, including the genera of *Australopithecus* and *Paranthropus*. The australopiths were small creatures who walked on two legs and lived in Eastern and Southern Africa for about 3 million years – from 4 million years to 1 million years ago. The group is diverse, with members of the genus *Australopithecus* being rather slender and graceful, and members of *Paranthropus* being robust, especially in the face. The australopiths were characterised by a combination of traits that may have improved fighting ability, including hand proportions that allow formation of a fist; effectively turning the hand into a club effective for striking.

Recently, University of Utah (USA) researchers David Carrier and Michael H. Morgan studied the bone structure of australopiths and found that the facial bones most often broken while fighting are the ones that have apparently become the strongest. For example, australopith faces and jaws were strongest in just those areas most likely to receive a blow from a fist. The researchers contend that human faces – especially those of our australopith ancestors – evolved to minimise injury from punches to the face during fights between males. The new study further found that the same face bones are also distinctly different between males and females. Scientists earlier believed this evolution in facial structure from the apes was primarily to adapt to a diet that included nuts, seeds and grass. However, the new study finds violence is a more likely contributor. Early humans would have fought over women and resources and this violence eventually led to the strengthening of the facial bones. (*Biological Reviews*, 9 June 2014 doi: 10.1111/brv.12112)

When modern humans fight hand to hand, the face is usually the primary target. The researchers found that the bones that suffer the highest rates of fracture in fights are the same parts of the skull that exhibited the greatest increase in robustness. These bones also show the greatest difference between males and females in australopiths and humans. In other words, male and female faces are different because the parts of the skull that are likely break in fights are bigger in males. Interestingly, the study also indicates that violence may have played a greater role in human evolution than is generally accepted by many anthropologists. ■