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

May 2013 Vol. 15 No. 8 Rs. 5.00

Math 2013
Mathematics of Planet Earth

Basics of Binary Search

Brahm Prakash
(Pioneer of Nuclear Materials in India)

(1912-1984)

Iteration number 1:

7	11	24	31	37	37	42	47	67	100

Middle number

Iteration number 2:

7	11	24	31

Iteration number 3:

24	31

Iteration number 4:

31

Middle number = Target number

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

A bottom up approach to strengthen S&T communication

Dr. R. Gopichandran

The Andhra Pradesh Akademi of Sciences and the Osmania University College for Women, Hyderabad recently organised an important national level conference on the opportunities to enhance interest in science streams in education. This was in response to a felt need to ensure a continual increase in the number of professional set to emerge in the future, with special interest in science and related educational research. These professionals would be expected to embellish academic and research activities in our country; central to sustainable development. Some important challenges in this context, highlighted by the discussants at the conference included: 1) perceived greater economic returns and job opportunities in areas other than science; 2) inadequacy of infrastructure because of which it is not easy to either demonstrate or co-involve students in exciting experiments; and 3) the diminishing trend of number of teachers of sciences. On the other hand such initiatives as the establishment of the Indian Institute of Science Education & Research in several parts of the country and the dynamic initiatives of the DST through its INSPIRE programme, were cited as positive enablers to tackle the challenges stated.

A related facet of the barriers appeared to be the overbearing nature of parents, implicated as not being able to recognise the value of science education vis-a-vis technical education. The latter includes engineering, technology, medicine, information technology and areas other than pure sciences. This is with special reference to job opportunities in particular.

Some of the interventions stated by the discussants included the need to orient teachers to state-of–the-art development in science and networking to help share knowledge and suggestions to improve infrastructure to deliver science education. It is essential to take note of the fact that these are often stated issues and options to overcome them. There are other equally important opportunities which however have to be recognised in order to solve these issues. The first and the foremost is the possibility that a large number of teachers are able to inspire students on their own despite these challenges by adopting innovative methods. It is also possible that such teachers are able to infuse values of perseverance and ability to innovate in the process of communicating science. We need to scout for such innovations and document them. Planners of education will be able to consider such case examples for suitable up-scaling; duly recognising the fact that these could be easily implemented with appropriate adaptation for immediate and local relevance. Teachers can also be invited to share the insights regarding innovations to create newer opportunities through collective knowledge hybridisation. Several State and national level initiatives can also consider creating a compendium of such innovations with the involvement of the State Councils of Science and Technology and other institutions engaged in science communication. This bottom-up approach will also confer the much needed recognition for teachers who deliver despite all odds.

Yet another often-cited reason is the tendency of parents to wean children away from less lucrative science pursuits. This completely discounts the bases of interest parents have on the career pathways or rewards for their children. Several socio-economic considerations may determine such promptings and cannot be brushed away as mere ignorance or as being less sensitive to the interest of the children. A holistic consideration of these determinants is therefore essential, duly recognising the need to enable and foster excellence and ensure rewards.

A recent publication of the Education, Audio Visual and Culture Exchange Agency of the European Commission (Science Education in Europe: National Policies Practices and Research, 2011. 166P. Education, Audiovisual and Culture Executive Agency, European Commission) also highlighted similar predicaments. Partnerships between schools and science related organisations have been indicated as a means of coming together to tackle these challenges. Such initiatives as TIMSS (Trends in International Mathematics and Science Study), PISA (Programme for International Student Assessment) and ROSE (Relevance Of Science Education) have been cited; with insights comparable with the Indian context. This includes an emphasis on the home background and the call to make learning an enjoyable experience. The coming together of the Andhra Pradesh Akademi of Sciences and the Osmania University College for Women, Hyderabad signifies a successful synergy in the Indian context; with reference to the European Commission insight. A large number of such deliberations is essential across our country to exert a positive influence through the bottom-up approach proposed. The compendium and its benefit cannot be over emphasised in this context.

Email: r.gopichandran@vigyanprasar.gov.in ■

Editor : Subodh Mahanti
Associate editor : Rintu Nath
Production : Manish Mohan Gore and Pradeep Kumar
Distribution : Harish Goyal
Expert member : Biman Basu
Address for correspondence : Vigyan Prasar, C-24, Qutab Institutional Area, New Delhi-110 016
Tel : 011-26967532; Fax : 0120-2404437
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.

Brahm Prakash

Pioneer of Nuclear Materials in India

Dr. Subodh Mahanti
E-mail: smahanti@vigyanprasar.gov.in

"In post-independence India, Dr. Brahm Prakash, the eminent metallurgist and administrator, played a major role in formulating and implementing research and development activities of far-reaching consequences in the Department(s) of Atomic Energy and Space. He was also vitally instrumental in establishing a firm base for self-reliance in many areas of advanced materials technology. In addition, his sphere of influence extended to several educational institutions, CSIR and Defence Laboratories…The achievements of Dr. Brahm Prakash made an indelible impact on the character and growth of science and technology in India for well over three decades,

C. V. Sundaram in *Biographical Memoirs of Fellows of the Indian National Science Academy*, Vol.16, 1993.

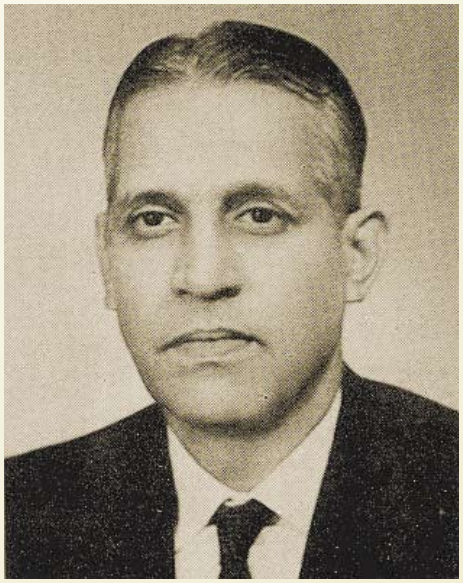
"His (Brahm Prakash's) humility did not consist merely in being modest about his talents or virtues, but in respecting the dignity of all those worked under him and recognizing the fact that no one is infalliable, not even the leader. He was an intellectual giant with a frail constitution; he had a childlike innocence and I always considered him a saint among scientists."

APJ Abdul Kalam in *Wings of Fire: An Autobiography*, 1999.

"Bhabha, Sarabhai, Dhawan, and Brahm Prakash stewarded the space programme with conviction and nobility of leadership — qualities which emboldened the ISRO community to delve into uncharted territory with confidence. The leadership was open to the fact, that while mastering technology mistakes will occur and the solution lay in understanding the issues, analysing them in depth and correcting them. These leaders were not risk-averse, but could take decision based on reasoned thinking. In turn, they groomed good leaders."

Rajaram Nagappa and Y. N. Rammurthy in their review of the Book, *A Brief History of Rocketry in ISRO* by PV Monoranjan Rao and P. Radhakrishnan, 2012 in *Current Science*, 2012.

Brahm Prakash is regarded as father of nuclear materials in India. He is one of those who put India's nuclear programme as visualised by Homi Jehangir Bhabha on a sound footing. He was also one of those who made significant contribution in laying the foundation of India's space programme. The separation of zirconium and hafnium achieved by Brahm Prakash was a path-breaking contribution, which made feasible the development of zircaloy cladding for nuclear fuel. He was the prime architect of the Nuclear Fuel Complex at Hyderabad. He was also the Chairman of the newly established Uranium Corporation of India Ltd., Jaduguda. Besides being one of the pioneers of India's nuclear programme, he was one of those who shaped India's space programme initiated by Vikram Sarabhai. He played an instrumental role in making India capable of building and launching its own satellite. Brahm Prakash shaped the metallurgical education and research in the country to a great extent. He was an inspiring leader and groomed many young scientists who later occupied key positions in India's science and technology programme. He was the first Indian to be appointed as Head of the Department of Metallurgy of the Indian Institute of Science, Bengaluru, and was the first Director of the Vikram Sarabhai Space Centre, Thiruvanthapuram.



Brahm Prakash

Brahm Prakash was a true *karma yogi*. His devotion to work was supreme and was not guided by personal ambitions. C.V. Sundaram wrote: "His achievements carried no touch of ostentation or self-consciousness. When a goal-oriented task was completed, there were no cheers or celebrations as he was shy of them. He moved on to another task, another pursuit, another mission with unflagging concentration."

Brahm Prakash was a great human being. He has been truly described as a saint among scientists. His personal characteristics have been beautifully described by his wife of four decades. She wrote: "Calling my association with him a 'divine order' does not embarrass me now, having lived with him for forty years. In the midst of raising a family under constraints, doing a demanding job, he never looked for easy options, never succumbed to any impure impulses or less dignified ways, never entertained unkind thoughts or words. Every moment of his life, he guarded his actions carefully in the light of his ultimate values — truthfulness, devotion to work and kind thoughts for all. This came spontaneously to him. He did not have to fight with himself to pour out such uniform goodness. That I was granted the boon of living with a person whose sight or contact, word or presence brought out the best in others was a divine experience for me." (Quoted in C. V. Sundaram, *Biographical Memoirs of Fellows of the Indian National Science Academy*, Vol.16, 1993.) Such qualities are indeed extremely rare to be found in a person. The qualities, 'truthfulness', 'devotion to work' and 'kind thoughts for all' should be considered as essential requirements for every citizen of the country.

Government College, Lahore

Brahm Prakash was born on 21 August 1912 in Lahore of undivided India (now in Pakistan). His parents were Khem Kaur and Jodha Ram Sekhri. His father worked in Indian Railways. He first studied at the Central Model School, Lahore and then joined the Sanatan Dharma College, Lahore from where he passed the Intermediate Science examination, standing first. After completing his Master Degree from the Government College in Lahore he worked as demonstrator in the same college. He began his first research work under the guidance of H. B. Dunicliffe. Brahm Prakash was deeply influenced by Dunicliffe. Later he worked with Shanti Swarup Bhatnagar. He studied magnetic characteristics of compounds of transition metals, and determined the chemical structure and valence states of some transition metals by measuring their magnetic susceptibilities. A number of chromium compounds were synthesised by him and he also derived the valence states of chromium in these compounds. His studies on chromium compounds cleared some of the existing controversies related to these compounds. He investigated crystallographic phase transformations in systems like MnS by using the technique of magnetic susceptibility measurement. As part of his PhD work he also investigated the role of particle size in chemical reactions; for example, reactions between H_2S and chromates of lead and silver. In 1942, Brahm Prakash obtained his PhD in Physical Chemistry from Panjab University.

S.S. Bhatnagar

After his PhD he proceeded to USA on a Government of India scholarship for higher studies. He first went to the Columbia University, but was told that the field of investigation in which he was interested could not be pursued there. He then went to Massachusetts Institute of Technology (MIT) for exploring the possibility of working there and started working there in metallurgy. At MIT he got the opportunity of interacting and working with accomplished metallurgists like John Chipman, Morris Cohen, A.M. Gaudin, and Reinhardt Schumann (Jr.). He obtained a Doctor of Science (ScD) degree from the MIT specialising in mineral dressing.

H.J. Bhabha

On his return to India in 1949, Bhatnagar recommended his name to Homi Jehangir Bhabha for a suitable position in the Atomic Energy Programme, which was in those days in its infancy. It may be noted that Bhabha was the architect of India's nuclear programme and Bhatnagar established a chain of national laboratories under the aegis of the Council of Scientific and Industrial Research (CSIR). Brahm Prakash was appointed in the Atomic Energy Programme as a metallurgist. However, at the time the Programme was just beginning and so he was deputed to the Indian Institute of Science, Bengaluru as Professor and Head of the Department of Metallurgy. In fact, he was the first Indian to head the Department. While at Bengaluru he was also supposed to plan and organise the metallurgy programme for atomic energy development. He spent six years (1951-57) at the Indian Institute of Science. He played an instrumental role in transforming the department as an excellent centre of teaching and research in metallurgy.

In 1957, Brahm Prakash came back to take up his original assignment at the Atomic Energy Establishment at Mumbai. His first important challenge was commissioning of the Fuel Fabrication Facility for producing aluminium-clad uranium fuel for the CIRUS, or Canadian-Indian Research Reactor. It had been decided that India would supply half of the initial fuel. The development of the fuel required that uranium metal should have a fine-grained structure so that the radiation growth in reactor service could be prevented. The uranium fuel developed by Brahm Prakash and his team was found to be even better than the Canadian fuel. It was indeed a great achievement. Brahm Prakash and his team also achieved the production of zircaloy clad UO_2 fuel for the first atomic power station at Kota, Rajasthan constructed with Canadian collaboration. Under the leadership of Brahm Prakash the metallurgy group of the Atomic Energy Establishment successfully achieved the establishment of facility for the fabrication and assembly of fuel elements for research and power reactors, a method for producing nuclear-grade zirconium, and establishment of facilities needed for plutonium extraction and fabrication of plutonium fuels. They also developed a detailed plan for the establishment of the Nuclear Fuel Complex at Hyderabad.

Bhabha had a great faith in the professional and leadership abilities of Brahm Prakash and so he entrusted diverse responsibilities to him. C.V. Sundaram, L.V. Krishnan and T.S. Iyengar wrote: "As an index of the deep trust that was placed by Bhabha in Brahm Prakash, it may be mentioned that the Metallurgy Group under Brahm Prakash was the largest group in Trombay, encompassing not only metallurgy but also programmes in the various chemistry disciplines, reactor engineering and operation, isotope production and applications, and even the engineering services."

Brahm Prakash was appointed Chairman of the newly established Uranium Corporation of India Ltd. at Jaduguda in 1967, a post which he held till 1981. He was also the Project Director of the Nuclear Fuel Complex, Hyderabad for the period 1966-72 and established this facility on a firm base. In fact, he was the prime architect of this facility established for developing all kinds of nuclear fuel elements.

Brahm Prakash was the first Director of the Vikram Sarabhai Space Centre (VSSC) at Thiruvanthapuram. It was Satish Dhawan, then the Chairman of ISRO, who brought in Brahm Prakash to shape this lead organisation of ISRO. The VSSC comprised the Thumba Equatorial Rocket Launching Station, Space Science and Technology Centre, Rocket Propellant Plant, Rocket

Vikram Sarabhai Space Centre, Thiruvanthapuram

Fabrication Facility, and Propellant Fuel Complex. He nurtured the VSSC in its formative phase by providing an able and inspiring leadership. MGK Menon wrote: "It was Dr. Brahm Prakash who brought success to welding all the amorphous entities, out of which it was composed and nurturing it to make it the dynamic structure it is today."

APJ Abdul Kalam recalls in his autobiography the advice given by Brahm Prakash for tackling big science project: "Big scientific projects are like mountains, which should be climbed with as little effort as possible and without urgency. The reality of your own nature should determine your speed. If you become restless, speed up. If you become tense and high-strung, slow down. You should climb the mountain in a state of equilibrium. When each task of your project is not just a means to an end but a unique event in itself, then you are doing it well." Brahm Prakash retired from VSSC in 1979.

Vikram Sarabhai

Professor Brahm Prakash Laboratory for Advanced Materials has been established in the Department of Metallurgy/Materials Science, Indian Institute of Science (IISc), Bengaluru. Prof. Brahm Prakash Memorial Materials Quiz is being organised by the Indian Institute of Metals, Kalapakkam Chapter. The idea behind the programme is to create awareness among students about the excitement of materials science and importance of metallurgy and materials in industrial and technological development. The quiz was originally started in 1990 but it was named after Brahm Prakash in 1993. A prize in the name of Brahm Prakash has been instituted by the Indian National Science Academy, New Delhi. A Brahm Prakash Chair for a Visiting Professorship has also been established in the Department of Metallurgy, IISc with the financial support of the Departments of Atomic Energy, Space and Science and Technology and the Defence Research and Development Organisation. The Indian Space Research Organisation (ISRO) has also established a Distinguished Professorship in the name of Brahm Prakash.

C.V. Sundaram

In 1955, Brahm Prakash was elected as one of the scientific secretaries for the First UN Conference on the "Peaceful Uses of Atomic Energy" held at Geneva. This was recognition of his professional competence. The paper, "Separation of hafnium and zirconium by vapour phase dechlorination" presented by him at the Conference was regarded as the first original pyrochemical approach of separation of hafnium and zirconium – two elements very similar to each other. Brahm Prakash was the President of the Indian Institute of Metals in its Silver Jubilee Year (1972). He was a member of the American Institute of Mining, Metallurgical and Petroleum Engineers and a Fellow of the Indian Academy of Sciences. The Government of India awarded him *Padma Shri* (1961) and *Padma Bhushan* (1968). Among other awards were: *Bhatnagar Award* (1963), *Bhatnagar Memorial Award* of INSA (1979) and Bralco Medal of the Indian Institute of Metals (1980).

Brahm Prakash died on 3 January 1984 in Mumbai.

Brahm Prakash was a *Karma Yogi* in the real sense. He worked not for his personal fame or gains but for his country. His achievements are truly remarkable. His personal attributes are worth emulating. The story of life and work of Brahm Prakash should be read and reread by every young Indian. It is true even today what C.V. Sundaram wrote in 1984: "To do any justice to the phenomenal content of the life and work of this great metallurgist and administrator, and to his total personality as an individual of rare quality, will require a considerable amount of patient research-gathering and collating information and impressions from all available sources, in order to present a complete account for the benefit of posterity." Almost one decade later, Sundaram wrote a somewhat comprehensive account of life and work of Brahm Prakash for the Indian National Science Academy. However, more remains to be done.

References

1. Kalam, APJ Abdul, *Wings of Fire: An Autobiography*, Hyderabad: Universities Press (India) Pvt. Limited, 1999.
2. Nagappa, Rajaram and YN Rammurthy, Review of the Book, *A Brief History of Rocketry in ISRO* by PV Monoranjan Rao and P. Radhakrishnan, Universities Press (India), Hyderabad, 2012 in Current Science, Voll.103, No.8, pp.946-947, 2012.
3. Raj, Gopal, *Reach for the Stars: The Evolution of India's Rocket Programme*, New Delhi: Viking/Penguin Books India (P) Ltd., 2000.
4. Sundaram, CV "Brahm Prakash (1912-1984) in *Biographical Memoirs of Fellows of the Indian National Science Academy*, Vol.16, New Delhi: Indian National Science Academy, 1993.
5. Sundaram, CV, "Remembering Professor Brahm Prakash", http://materials.iisc.ernet.in/~www/archives/people/brahm.html (The article was written on the occasion of the Golden Jubilee of the Department of Metallurgy, Indian Institute of Science, Bengaluru (Brahm Prakash was the first Indian head of the department).
6. Sundaram, CV, LV Krishnan and TS Iyengar, *Atomic Energy in India: 50 years*, Government of India, Department of Atomic Energy,1998.
7. "Tributes paid to Brahm Prakash", *The Hindu*, 21 August 2001.
8. Available sources on the Internet.

(The article is a popular presentation of the important points of the life and work of Brahm Prakash available in the existing literature. The idea is to inspire the younger generation to know more about Brahm Prakash. Te author has given the sources consulted for writing this article. However, all the sources on the Internet have not been individually listed. The author is grateful to all those authors whose works have contributed to writing this article and also to the sources of the photographs/ illustrations used in the article.)

Basics of Binary Search

Rintu Nath
E-mail: rnath@vigyanprasar.gov.in

A few days back my uncle gave me a book, titled Cabinet of Mathematical Curiosities, written by Professor Ian Stewart. The book has many interesting mathematical puzzles and a number of unsolved mysteries. A few mathematical problems could not be solved for centuries. The Clay Mathematics Institute in Cambridge, Massachusetts, USA, offers seven prizes, each of 10 million US dollars for definitive solutions of seven major open problems. I was totally engrossed while reading the book and found it very interesting.

One evening, I was reading the book and trying to solve a few mathematical puzzles given in the book. My uncle smiled and said, 'My dear Googol, it seems that you liked the book very much.'

'Yes uncle. I find these mathematical puzzles very interesting. I am also thrilled to know there are so many unsolved mathematical mysteries!' I replied.

'It's good to see that you enjoyed those mathematical puzzles. As you engage yourself more in the world of mathematics, you will experience the thrill of discovering the new world.'

'Thank you, uncle.'

'Here is a simple but famous hotel problem for you Googol. Three persons went into a hotel. They booked one room at Rs 300 a night, each sharing Rs 100. A short while later the manager directed the booking clerk to charge Rs 250 a night. After receiving Rs 50 back, they offered Rs 20 as tip to the booking clerk and shared the remaining Rs 30 equally. That means each person had actually spent Rs 90, that is, a total of Rs 270 plus Rs 20 as tip. This adds up to Rs 290. Then where is the remaining ten rupees?' Uncle wanted to know.

'I have heard about this problem and every time it puzzles me despite knowing it is not possible. Please explain.'

'Well Googol, if you focus on the total expenditures, then it includes the amount spent on the rent of the room plus the tip to the clerk, which is Rs 250 + Rs 20 = Rs 270. Hence, each person indeed spent Rs 90, and therefore three persons spent 3 x Rs 90 = Rs 270. There is no conflict at all.' Uncle explained.

'It is surprisingly easy! I think that the trick is in the way the question is framed, which then leads to calculation of the total expenditures incorrectly,' I said.

'It was just a simple mathematical trick, which may not be considered a true mathematical puzzle. Mathematical puzzles are supposed to give you the opportunity to think and derive a method to solve problems. Here is a true mathematical puzzle for you: I have twelve identical-looking coins. However, one coin is heavier than the rest. You have one basic weighing scale, having two pans to compare weights of objects kept in two pans. How many times do you need to weigh to trace the heavier coin?'

> Mathematical puzzles are supposed to give you the opportunity to think and derive a method to solve problems

'Uncle, if I take two coins at a time and place one on each pan, I should be able to trace the heavier coin in six comparisons. If two coins have the same weight, the weighing scale will be in a balanced position; otherwise it will be tilted towards the heavier coin. If I am lucky, I may be able to trace it even at the first go.'

'But Googol, if I have one hundred coins and your luck doesn't favour, you may have to do fifty comparisons to trace the heavier coin! '

'Is there a better way to do this?' I wanted to know.

'Certainly, there is. Partition the coins into two equal groups. You will get six coins in each group. Now place six coins in one pan and the remaining six to the other pan. The weighing scale will tilt towards the group having the heavier coin. Take this group and discard the other. Again make two groups having three coins in each group. Compare their weights. Consider the heavier group and discard the other. Now you have three coins and you are certain that the heavier coin is one of the three coins. Now take any two coins from this group and put them on the weighing scale. If they are of equal weights, then the third one is the heavier one, otherwise the scale will tell you which coin is the heavier one. So you can make the decision in three steps.'

> The word *binary* signifies two, which means that during the search operation we continuously partition all elements in two groups. Hence the name of the method is *binary search*

'Uncle, the method explained by you will need three steps to trace the heavier coin. Comparing the weight of two coins at a time would have taken a maximum of six steps. However if I am lucky I may need only one step!'

'True. For small number of coins there will not be a big difference. However Googol, if you need to search the heavier coin out of one hundred coins, the method will require seven steps to trace the heavier coin and you are not dependent on your luck! If you have to search the heavier coin out of one thousand coins you will need only ten steps. Also, if you get groups with odd number of coins, then while halving the coins, you may be lucky to make the decision earlier. Moreover, mathematically speaking, if we have to do a similar calculation again and again, we should not depend on luck. Rather, we should focus on the approach that will be the best on average.' Uncle explained.

'I understand now. Comparing two coins at a time will be almost impossible if number of coins increases substantially. However, as you have mentioned, if we group them into two and after each comparison discard one group and again form two groups from the selected one, on average we will need fewer steps.'

'Yes Googol, that's precisely the case!'

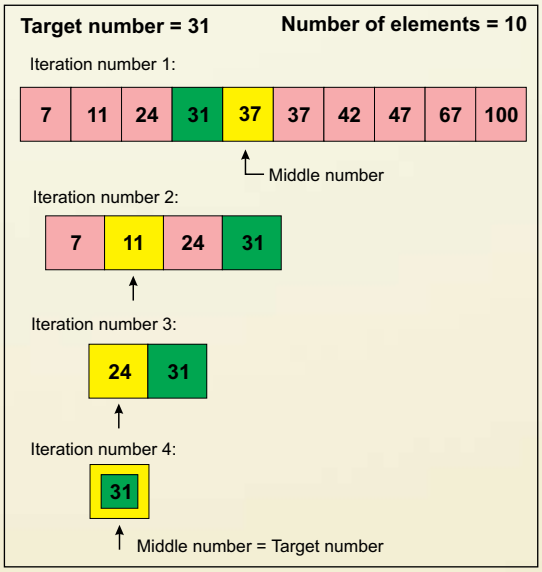
'I presume that there must be some applications of this rule in real world.' I wondered.

'You are right. In computational world, a very similar logic of searching algorithm is used. This is known as '*binary search*'

or '*half-interval search*'. The word *binary* signifies two, which means that during the search operation we continuously partition all elements in two groups. Hence the name of the method is *binary search*.' Uncle said.

'Please explain more about the binary search,' I urged.

'Let's say there is a list (or array) of the following ten numbers (also called elements): (7, 11, 24, 31, 37, 41, 42, 47, 67 and 100). Now, I may be interested to know if the number 31 is in the list (target number), and also the position of the number if it is present in the list. Let's see how the computer will work out this query using the simplest approach, also called 'linear search' algorithm. The computer will look into the each element in the list and check each element for equality with the target number; i.e., if X = 31, where X is a number in the list. It will continue to search until it finds the target number or reaches the end of the list. If it finds it, then it notes the index or position of the number in the list. If it cannot find the element in the list, it will then return zero indicating that the target number is absent in the list. Well, tell me how many comparisons (or iterations) this algorithm needs to find the target number if the list contains the numbers in random order.' Uncle asked.



'If the numbers are in random order, it could be possible that the target number is at the very first position of the list just by chance. So it should get the answer at the very first comparison.'

'Very good, Googol. For the linear search, the best speed that can be achieved is a single comparison. However, in the worst case scenario, it will take N comparisons to tell us if the target number is in the list or not where N is number of elements in the list. On average, the linear search will take $(N+1)/2$ comparisons.'

'I got it uncle. What about the binary search then?'

'Before applying the binary search on a list of numbers, it is important that we *sort* the numbers or elements in the list. For example, the numbers in our list are already sorted in *ascending order*. During the binary search, the computer will focus on the middle or approximately middle element of the sorted data and partition the data into two groups. For a list with *odd number of elements* (i.e., N is odd), there is a single middle element, and hence each partitioned group will include $(N-1)/2$ elements. For a list with *even number of elements* (i.e., N is even), two groups contain $(N/2-1)$ and $N/2$ elements. Note that here the group on the left side of the middle number will include numbers that are less than the middle number. The computer will then check if the middle number is equal to the target number. If true then it will stop searching. However, if the middle number is greater than the target number, then it will discard the group on the right side since it has all numbers greater than the target number. It will then partition the group on the left side again into two groups containing equal (or approximately equal) number of elements. On the other hand, if the middle number is less than the target number, then the same operation will be done on the groups of numbers on the right side. The whole process is repeated continuously with elimination of one group and retaining the other until only one element is remaining and then the computer check it for equality.'

> Before applying the binary search on a list of numbers, it is important that we sort the numbers or elements in the list

'That sounds very interesting. Let me give it try on the list of our numbers (7, 11, 24, 31, 37, 41, 42, 47, 67, and 100), which is already sorted in ascending order. We consider the target number be 31. The list includes even number of elements. Let's take the middle number as 37 and therefore, the group on the left side contains five numbers (7, 11, 24, and 31) and the group on the right side contains five numbers (41, 42, 47, 67 and 100). The middle number is not the target number (37 ≠ 31). Now, we have to check the condition: 37 > 31. This is true and thus we can exclude the group on the right side. In next step, the middle number is 11 and it is not the target number. The condition 11 > 31 is false. So we will exclude the group on the left side (7). Now the middle number is 24. The condition 24 > 31 is false. Therefore discard the group on the left side. Therefore only one number (31) is remaining, and the algorithm will test this number for equality with the target number which is true. So the algorithm will find the target number 31 in the given list of numbers.' I said.

'Yes, you did it correctly.' Uncle explained.

'Uncle, the comparison could use either 'greater than' or 'less than' operation to reach the same conclusion.'

'Yes, either 'greater than' or 'less than' operation can be used in a binary search, but obviously not both operations at the same time!'

'Can binary search also return the position of the target element?' I enquired.

'Yes, before sorting the numbers, it is possible to note the index of the number and move the index along with the number. Once the target number is found, it is not difficult to find the index attached with the number.'

'What about the computational speed using this algorithm?'

'The method of binary search algorithm reduces the search time significantly and is particularly useful in computer programming. As we have seen in our example on finding the heavier coin, a binary search reduces the number of comparisons drastically when N is very big. Mathematically speaking, to locate an item (or determining its absence or presence) by binary search, the number of comparisons is reduced logarithmically.'

'I did not get that uncle. Could you please explain it further?'

'From the previous example, let me phrase the concept of binary search in

Continued on page 26

The Curious World of Numbers

Dr. C.K. Ghosh
E-mail: ckghosh@ignou.ac.in

Introduction

The first encounter of a child with mathematics takes place through numbers. As he progresses further he switches over to symbols (in algebra) or lines and figures (in geometry). But numbers remain as the base. Development of affinity with numbers helps in creating interest in mathematics and removing the fear psychosis about the subject which is quite prevalent among a large number of students and even their guardians.

The inspiration behind this article is Srinivasa Ramanujan, who was known as the wizard of numbers. The objective is to give the reader an exposure to the world of many curious numbers having peculiar and interesting properties with the hope that it would create in them a love for the subject.

The inspiration behind this article is the life and works of the famous Indian mathematician, Srinivasa Ramanujan. He was a mathematician with exceptional talent and intuitive power. He made very significant contributions in various branches of mathematics, the most conspicuous among them being 'number system'. He was called the 'Wizard of numbers'. As a tribute to him, our endeavor is to sensitize the readers to the fact that mathematics is not a subject to be afraid about; rather it can be a great fun and we are doing so by dealing with curious properties of many interesting numbers. A particular number '1729' is named after Srinivasa Ramanujan. Let us begin our discussion with that.

The Ramanujan Number(1729)

The story behind the Ramanujan number, 1729 goes like this.

Ramanujan used to remain unwell most of the time when he was abroad. His mentor G.H. Hardy, who himself was a famous mathematician, used to take care of Ramanujan's health when he was abroad. Almost daily he used to scold Ramanujan for not taking due care of his health, food, medicines, etc., regularly. One of those days when he came to meet Ramanujan in hospital, Hardy was looking quite morose whereas Ramanujan was quite cheerful. Ramanujan asked his mentor as to why he was looking so upset. Hardy replied that for coming to the hospital, he hired a taxi, and he found its number very boring. "What was that number?" Ramanujan asked. Hardy replied, "It was 1729."

Ramanujan immediately replied that there could not be a more exciting and interesting number than 1729. There are very few numbers which can be expressed as the sum of two cubes in two different ways. 1729 is the least among them. A few unique characteristics of this number are given below:

Significance of the Ramanujan Number (1729)

1) It is the least number which can be expressed as the sum of two cubes in two different ways:

$$12^3 + 1^3 = 1728 + 1 = 1729$$
$$10^3 + 9^3 = 1000 + 729 = 1729$$

2) However, if we consider negative integers also, then '91' is the least number.

$$4^3 + 3^3 = 64 + 27 = 91$$
$$6^3 + (-5)^3 = 216 + (-125) = 216 - 125 = 91$$

Incidentally '91' is a factor of 1729.

3) The other numbers which can be expressed as the sum of two cubes in two different ways are the following:

4104	=	$16^3 + 2^3 = 15^3 + 9^3$
13832	=	$24^3 + 2^3 = 20^3 + 18^3$
40033	=	$34^3 + 9^3 = 33^3 + 16^3$
64232	=	$39^3 + 17^3 = 36^3 + 26^3$
110808	=	$48^3 + 6^3 = 45^3 + 27^3$
149389	=	$53^3 + 8^3 = 50^3 + 29^3$
171288	=	$55^3 + 17^3 = 54^3 + 24^3$
842751	=	$94^3 + 23^3 = 84^3 + 63^3$
2418271	=	$134^3 + 23^3 = 116^3 + 95^3$
7620661	=	$174^3 + 133^3 = 196^3 + 45^3$

4) The product of all factors of 1729 is equal to the 4th power of 1729.

$1 \times 7 \times 13 \times 19 \times 91 \times 133 \times 247 \times 1729 = 1729^4$

5) The sum of all factors of 1729 except itself can be expressed as the difference of two cubes.

$1 + 7 + 13 + 19 + 91 + 133 + 247 = 8^3 - 1^3$

6) 1729 can be expressed as the difference of two squares in four different ways:

$$1729 = 1729 \times 1 = (865 + 864)(865 - 864) = 865^2 - 864^2$$
$$= 247 \times 7 = (127 + 120)(127 - 120) = 127^2 - 120^2$$
$$= 133 \times 13 = (73 + 60)(73 - 60) = 73^2 - 60^2$$
$$= 91 \times 19 = (55 + 36)(55 - 36) = 55^2 - 36^2$$

7) Harshad Number

If the sum of the digits which constitute a natural number is a factor of the number itself then the number is called a Harshad Number. 1729 is a Harshad Number.

$1 + 7 + 2 + 9 = 19$, which is a factor of 1729

8) Carmichael Number

A non-prime natural number 'n' is called a Carmichael Number if

i) 'n' is **not** a perfect square

ii) The prime number 'p' is a factor of 'n', then (p-1) will be a factor of (n-1).

The first three Carmichael Numbers are respectively 561, 1105 and 1729.

$561 = 3 \times 11 \times 17$; 2, 10 and 16 are all factors of 560

$1105 = 5 \times 13 \times 17$; 4, 12 and 16 are all factors of 1104

$1729 = 7 \times 13 \times 19$; 6, 12 and 18 are all factors of 1729

9) 1, 81, 1458 and 1729 are again a peculiar class of numbers. If the digits constituting the said numbers are added and the sum is expressed in the reverse order, then the product of this sum and its reverse order generates the number concerned.

For example,

(1) $\rightarrow 1 \times 1 = 1$

(81) $\rightarrow 8 + 1 = 9;\ 9 \times 9 = 81$

(1458) $\rightarrow 1 + 4 + 5 + 8 = 18;\ 18 \times 81 = 1458$

(1729) $\rightarrow 1 + 7 + 2 + 9 = 19;\ 19 \times 91 = 1729$

10) 'e' is a transcendental number. So it is a non-recurring and non-

terminating decimal.

Incidentally the 1729th place onward up to the tenth place, both inclusive, are the numbers 1, 2, 3, 4, 5, 6, 7, 8, 9, 0.

1729th place marks the first occurrence of such a sequence.

Now, remembering Srinivasa Ramanujan, let us present some more interesting numbers.

Some more interesting numbers

- What is common between the numbers 153, 370, 371 and 407?

  You can observe that

  $1^3 + 5^3 + 3^3 = 1+125+27 = 153$

  $3^3 + 7^3 + 0^3 = 27+343+0 = 370$

  $3^3 + 7^3 + 1^3 = 27+343+1 = 371$

  $4^3 + 0^3 + 7^3 = 64+0+343 = 407$

  Similarly, we have three such four-digit numbers, 1634, 8208 and 9474. It can be seen that,

  $1^4 + 6^4 + 3^4 + 4^4 = 1 + 1296 + 81 + 256 = 1634$,

  $8^4 + 2^4 + 0^4 + 8^4 = 4096 + 16 + 0 + 4096 = 8208$, and

  $9^4 + 4^4 + 7^4 + 4^4 = 6561 + 256 + 2401 + 256 = 9474$.

  There are three such five-digit numbers, 54748, 92727 and 93084 and one such six-digit number, 548834. These numbers are called *Narcissistic Numbers.* The highest possible number of digits for which we can get a *Narcissistic Number* is 39. Given below is the list of all Narcissistic Numbers (Starting from seven-digit numbers).

  It would require some patience on the part of the reader to verify the truth of this very special feature of these numbers, but keeping in mind the interest it would generate it is hoped that the reader will go for the venture.

- What is common between 145 and 40585?

  We know that, $n! = n\,(n-1)\,(n-2)\ldots 3.2.1$

  $\therefore\ 1! = 1,$

  $4! = 4\,(4-1)\,(4-2)\,(4-3) = 4 \times 3 \times 2 \times 1 = 24$

  $5! = 5\,(5-1)\,(5-2)\,(5-3)\,(5-4) = 5 \times 4 \times 3 \times 2 \times 1 = 120$

  Now, $1 + 24 + 121 = 145$

  $\therefore\ 1! + 4! + 5! = 145$

  Again,

  $4! = 24$

  $0! = 1$

  $5! = 5.4.3.2.1 = 120$

  $8! = 8.7.6.5.4.3.2.1 = 40320$

  $5! = 5.4.3.2.1 = 120$

  Now, $24 + 1 + 120 + 40320 + 120 = 40585$

  $\therefore\ 4! + 0! + 5! + 8! + 5! = 40585$

- *What is common between the pairs* (12,42); (12,63); (12,84); (13,62); (23,96); (24,63); (24,84); (26,93); (36,84); (46,96); (14,82); (34,86); (23,64); and (13,93) ?

  We see that, 12×42=504 *and* also, 21×24=504. So, 12×42 = 21×24. Thus (12, 42) is a peculiar pair of two-digit numbers that has the same product when both numbers are reversed. Every other pair given above is like that. We observe that,

  $12 \times 63 = 21 \times 36$

  $12 \times 84 = 21 \times 48$

Table -1. Narcissistic Numbers

Digits	Narcissistic Numbers
7	1741725, 4210818, 9800817, 9926315
8	24678050, 24678051, 88593477
9	146511208, 472335975, 534494836, 912985153
10	4679307774
11	32164049650, 32164049651, 40028394225, 42678290603, 44708635679, 49388550606, 82693916578, 94204591914
14	28116440335967
16	4338281769391370, 4338281769391371
17	21897142587612075, 35641594208964132, 35875699062250035
19	1517841543307505039, 3289582984443187032, 4498128791164624869, 4929273885928088826
20	63105425988599693916
21	128468643043731391252, 449177399146038697307
23	21887696841122916288858, 27879694893054074471405, 27907865009977052567814, 28361281321319229463398, 35452590104031691935943
24	174088005938065293023722, 188451485447897896036875, 239313664430041569350093
25	1550475334214501539088894, 1553242162893771850669378, 3706907995955475988644380, 3706907995955475988644381, 4422095118095899619457938
27	121204998563613372405438066, 121270696006801314328439376, 128851796696487777842012787, 174650464499531377631639254, 177265453171792792366489765
29	14607640612971980372614873089, 19008174136254279995012734740, 19008174136254279995012734741, 23866716435523975980390369295
31	1145037275765491025924292050346, 1927890457142960697580636236639, 2309092682616190307509695338915
32	17333509997782249308725103962772
33	186709961001538790100634132976990, 186709961001538790100634132976991
34	1122763285329372541592822900204593
35	12639369517103790328947807201478392, 12679937780272278566303885594196922
37	1219167219625434121569735803609966019
38	12815792078366059955099770545296129367
39	115132219018763992565095597973971522400, 115132219018763992565095597973971522401

$13 \times 62 = 31 \times 26$
$23 \times 96 = 32 \times 69$
$24 \times 63 = 42 \times 36$
$24 \times 84 = 42 \times 48$
$26 \times 93 = 62 \times 39$
$36 \times 84 = 63 \times 48$
$46 \times 96 = 64 \times 69$
$14 \times 82 = 41 \times 28$
$34 \times 86 = 43 \times 68$
$23 \times 64 = 32 \times 46$
$13 \times 93 = 31 \times 39$

- What is common between the numbers, 6, 28, 496, 8128 ?

These belong to a class of numbers known as the 'Perfect Numbers'. Each number can be expressed as the sum of all factors of the number excluding itself but including '1'.

For example, the factors of '6' excluding itself and including '1' are 1,2, and 3, and we have,

$6 = 1 + 2 + 3.$

The factor of '28' excluding itself and including '1' are 1, 2, 4, 7, and 14, and we have,

$28 = 1 + 2 + 4 + 7 + 14.$

Similarly,

$496 = 1 + 2 + 4 + 8 + 16 + 31 + 62 + 124 + 248$

And

$8128 = 1 + 2 + 4 + 8 + 16 + 32 + 64 + 127 + 254 + 508 + 1016 + 2032 + 4064.$

There are prescribed methods for generating 'Perfect Numbers'. But that discussion is beyond the scope of this article.

Some interesting properties of the number '37'

My attention goes to the number '37' which is a prime first because, 37 + 100 = 137 and it is the reciprocal of the fine structure constant used in physical sciences. It is a fundamental constant given by the ratio of the square of the charge on an electron to the product of rationalised Planck's constant and the speed of light. It is remarkable that the numerator of the ratio involves an extremely conspicuous fundamental constant and the denominator involves the product of two fundamental constants which guide the micro and the macro world.

Again, as has been seen above, 370 and 371, whose first two digits create the number, '37' are the two among the four three-digit Narcissistic Numbers.

Now, let us leave alone numbers such as 137, 370 and 371 and concentrate directly on '37'. We shall come across many interesting properties as detailed under:

a) One can observe that, the sum of its digits multiplied by itself is equal to the sum of the cubes of its digits,

$10 \times 37 = 370 = 27 + 343$

$\therefore (3+7) \times 37 = 3^3 + 7^3$

b) The product of the digits when subtracted from the sum of the squares of the digits, the original number is obtained.

$(3^2+7^2) - 3 \times 7 = (9 + 49) - 21 = 58 - 21 = 37$

c) We observe that,

$37 \times 3 = 111$, $37 \times 6 = 222$, $37 \times 9 = 333$
$37 \times 12 = 444$, $37 \times 15 = 555$, $37 \times 18 = 666$
$37 \times 21 = 777$, $37 \times 24 = 888$, $37 \times 27 = 999$

d) Now, let us take three-digit multiples of 37 (other than 3, 6, 9). The first is 37 × 4 = 148. We juxtapose the digits by way of end-around carry to get the number 814 and 481. We find that these are also multiples of 37. 22 × 37 = 814, 13 × 37 = 481. Again, 37 × 5 = 185 and 518, 851 are both multiples of 37.

$14 \times 37 = 518$, $23 \times 37 = 851$

The readers may verify for 37 × 7 = 259 and 37 × 8 = 296

The property (c) of '37' can be used to present a very interesting game of mathematics.

Suppose, we ask somebody to write a three-digit number, and he writes 512. You quickly add 154 on the left as well as on the right side to get the numbers 154,512 and 512,154. Each of them is divisible by 37. Again suppose someone else writes 234 and then you quickly add 321 on the left as well as on the right side to get the numbers 321,234 and 234, 321. Again, each of them is exactly divisible by 37.

Now, why does it happen like that!

You may observe that in each case we are adding a three-digit number such that the sum of the given three-digit number and the additional one in a three-digit number where all three digits are same. In the first case, the sum in 154 + 512 = 666 and in the second case, it is 321 + 234 = 555. We have seen through property (c) that these numbers are divisible by 37. Again we know that 37 is a factor of 999 = 1000 – 1.

Now,

$$\begin{aligned} 154, 512 &= 154{,}000 + 512 \\ &= 154 \times 1000 + 512 \\ &= 154 \times (999 + 1) + 512 \\ &= 154 \times 999 + 154 + 512 \\ &= 154 \times 999 + 666. \end{aligned}$$

Each number on the right hand side is divisible by '37'. So the number is divisible by 37.

It is not necessary that while identifying the three-digit number, you have to make the sum always like 444, 555, 666, etc. You can target any number divisible by 37. Like, if the person has chosen 217, you make it 153, 217, because 153 + 217 = 370 = 37 × 10.

Now,

$$\begin{aligned} 153, 217 &= 153{,}000 + 217 \\ &= 153 \times 1000 + 217 \\ &= 153 \times (999 + 1) + 217 \\ &= 153 \times 999 + 153 + 217 \\ &= 153 \times 999 + 370 \end{aligned}$$

Again, each number on the right hand side is divisible by 37. So the number is divisible by 37. You can even create a nine-digit number. The trick is that you pretend to make a six-digit number and split the three-digit number into two groups of three-digit numbers. For example, if the number given is 241 then rather than putting 314 to make '555', you split '314' into say '103' and '211' to get 241, 103, 211, which is 37 × 6516303 and hence exactly divisible by 37. One can see that,

$$\begin{aligned} 241, 103, 211 &= 241 \times 999999 + 103 \times 999 + 241 + 103 + 211 \\ &= 241 \times 999999 + 103 \times 999 + 555, \end{aligned}$$

where each number on the right hand side is exactly divisible by 37, which establishes the logic behind the trick.

We shall conclude this article by discussing a trick of finding an unknown number.

Trick

You ask your friend to pick a number between 1 and 1000, both

Table -2. Ten questions

Sl No.	Question	Answer	Remarks and conclusion
1.	Is it greater than 500?	Yes	Add 250
2.	Is it greater than 750?	No	Subtract 125
3.	Is it greater than 625?	Yes	Add 62 and not 62½
4.	Is it greater than 687?	No	Subtract 31
5.	Is it greater than 656?	Yes	Add 16 and not 15½
6.	Is it greater than 672?	No	Subtract 8
7.	Is it greater than 664?	Yes	Add 4
8.	Is it greater than 668?	Yes	Add 2
9.	Is it greater than 670?	Yes	Add 1
10.	Is it greater than 671?	Yes	Applying the answer of (6), we conclude that the number is 672.

inclusive. You will now ask him ten questions to find out the number. But while asking the questions you have to remember that your friend will answer only in 'Yes' or 'No'. What will be the questions?

The crux of the problem is $2^{10} = 1024$, which is greater than 1000. This provides the desired hint for framing the questions. Each question should be such that half of the numbers are knocked out. The strategy of progressing with the questions will be such that with each subsequent question again half of the remaining numbers at each stage is knocked out. Thus after getting the answer to the tenth question, you can fix the number picked by your friend. Let us see how.

Let the number picked by your friend be 672.

Now, let us see the progress of questions presented in a table 2.

Conclusion

Handling numbers is indeed fun. Here we have presented only a few examples. There can be many examples about such peculiar numbers. The author shall consider his efforts rewarded if the reader takes a plunge into the curious world of numbers and thereby develop a love for mathematics and spread it among others.

Dr. C. K. Ghosh, Director, NCIDE, IGNOU, New Delhi ■

Continued on from 30 (Basics of Binary Search)

simple words. Essentially, if you do a binary search, this means you divide N numbers by 2 repeatedly until you end up with only one number. So the question is: How many times do you need to divide? In mathematical term, we can state this as:

$\frac{N}{2^x} = 1$; In other words, $2^x = N$, where x is the number of division required.

If you do a simple logarithmic calculation with base 2 (taking log2 on both sides), this can easily be shown that $x = log_2N$, which means that you divide log_2N times until everything is divided or you need to do a maximum number of log_2N divisions before you can find one single element. If you consider checking when the last number equals to the target number, then you need to do equality check. So the total number of comparisons will be $log_2N + 1$.'

'What is the best, worst and average number of comparisons for the binary search?'

'In general, for the binary search, the best case scenario is expressed as $floor(log_2N)+1$, where the expression '$floor(x)$' means that you need to take the largest integer which is not greater than x. Similarly, for the worst case scenario, it is expressed as $ceiling(log_2N)+1$where the expression '$ceiling(x)$' means that you need to take the smallest integer which is not less than x. On average, the binary search will make $log_2N + 1$ comparisons.'

'Okay, this means that on average, the linear search will make $(N+1)/2$ comparisons while the binary search will make $log_2N + 1$ comparisons. Clearly, when N is very large, the binary search will be very efficient.'

'You are right Googol. In the worst case scenario also, the linear search will make N comparisons and it is evident that the binary search is substantially faster as N grows very large. For example, for a list of 100 numbers, the average number of comparisons will be 50.5 by the linear search and 7.64 by the binary search. If you have to search a list of one million elements, then it takes as many as one million comparisons with the linear search, but never more than twenty comparisons with the binary search.'

If you have to search a list of one million elements, then it takes as many as one million comparisons with the linear search, but never more than twenty comparisons with the binary search

'Is it possible to increase the efficiency of binary search algorithm?'

'Yes. The algorithm I have explained checks for equality as well as inequality. In case of equality, that is, when the middle number is equal to the target number, the search algorithm will return a 1, indicating that the number is present and thereafter it terminates. However, this requires two checks at each stage. This option could be ideal for the best case scenario, but it will also slow down the algorithm on average. In case of extremely large number of data the algorithm may be modified to check only for inequality. Equality check is done only when only one element is left. This works best in the worst case scenario.'

'What will be returned by these search algorithms if an element exists multiple times in the list?'

'If there are multiple targets in the list, both searches will find only one instance. If the target element is missing in the list, both searches will conclude the same. If the target element is missing, it is like the worst case scenario, and we have already noted that the binary search will work more efficiently in this situation.'

'Uncle, I realised now that the computer executes such a complex and efficient algorithm behind the scene to do an operation that looks so simple at first instance. I am quite fascinated by the sheer elegance and efficiency of the binary search. Thanks very much for explaining this.' ■

Green Nanotechnology: Solution for Clean Drinking Water

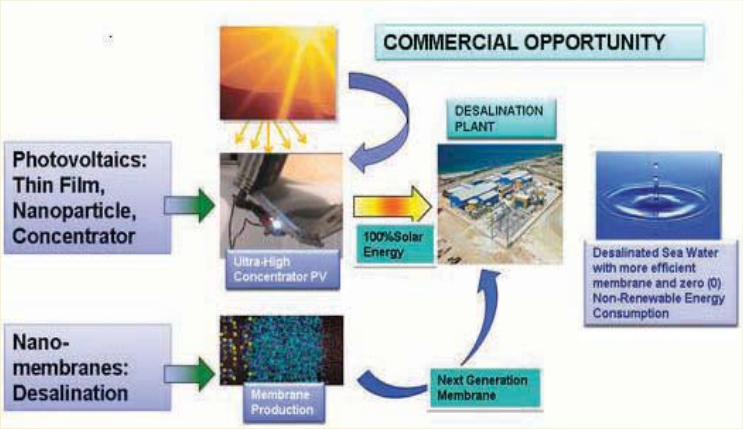
Monika Koul
E-mail: drmkoul@gmail.com

Population increase is an issue and challenge which every country across the world is facing. United Nations population data suggest that world population will be more than 7 billion in a few years and is not expected to stabilise. Malthus in his historical essay on population rise clearly predicted that population will increase geometrically and resources will not match the steep increase. In order to meet the needs of this increasing population, the need for more food, water, housing, transportation, consumer goods, social services, and energy is growing at a very fast pace. Natural resources have been overexploited and degraded to meet the growing needs. Depletion of resources has gone to an extent that nothing much can be done about its restoration.

However, technological and scientific interventions and basic and applied sciences can change the course and help humanity in some way. One of the recently developed methodologies that mankind can rely on is the nano-science technology or nanotechnology. Nanotechnology is the branch of science that makes use of materials whose structures have characteristic features on the nanoscale, i.e., on the scale 10^{-9} metre. This size is very small as compared to objects we see around us. This science is based on principles of atomic and molecular attributes and properties. Hence, a good grasp and thorough understanding of solid state physics and other scientific disciplines is important.

Nanomaterials have unique charactersitics that are attributed to their unassumingly small sizes and are going to provide novel applications and solutions to many of the present environmental problems. This new field that is emerging to tackle the environment related problems and offer scientifically viable solutions is called 'Green nanotechnology'. Green nanotechnolgy can help in providing energy, clean water and good environment in a sustainable way.

One of the emerging fields where green nanotechnolgy is helping is in water sector. Supply of drinking water to the growing population is a challenge to countries across the global. Water is also required for energy generation, for irrigation of crops, and for industrial activities. But, although Earth has plenty of water, it is no longer fit for human consumption. Majority of the water reserves are polluted and contaminated with both organic and inorganic waste. Salinity of water is another major aspect that needs to be dealt with. Scientists are looking at nanotechnology as an important tool and hope to tackle many problems. How nanotechnology intervenes and can provide solutions to water problems is an interesting area of research.



Nanotechnology based water purification system. The system is highly effective and decontaminates water from all sorts of impurities and requires low inputs and is cost effective.
Source: World Wide Web

Water is purified by various methods such as physical, chemical, and biological treatments. Treatment method mainly depends on the purpose and use which water is put to. With each method, different types of pollutants are removed to some degrees. However, none of mentioned methods guarantee the absolute purity because of various technical flaws associated with the methods. Some of the methods incur huge financial inputs and some are time consuming. Green nanotechnology offers solutions to many of these problems and is considered an important technological improvement. Water purification using nanotechnology exploits nanomaterials such as carbon nanotubes and alumina fibres for nanofiltration. It also utilises the existence of nanoscopic pores in zeolite filtration membranes, as well as nanocatalysts and magnetic nanoparticles. Nanosensors, such as those based on titanium oxide nanowires or palladium nanoparticles are used for analytical detection of contaminants in water samples. These sensors are being used as monitoring agents for determining water quality. Nano absorbents with high capacity and selectivity can remove cations, anions, and organic solutes from highly contaminated water of lakes and ponds. They can be used for removal of sediments, chemical effluents, charged particles, bacteria and other pathogens from river water as well. Toxic trace elements such as arsenic, lead, and cadmium, and viscous liquid impurities such as oil can also be removed using nanotechnology.

Carbon nanotube membranes act as molecular sieves and can remove almost all kinds of water contaminants including turbidity, oil, bacteria, viruses, and organic contaminants. This technology is seen as a new hope when water gets contaminated from leakage of oil tankers as happened off the Mumbai coast last year. Although their pores are significantly smaller, carbon nanotubes have shown to have an equal or a faster flow rate as compared to larger pores, possibly because of the smooth interior of the nanotubes. Nanofibrous alumina filters and other nanofibre materials also remove negatively charged contaminants, and organic and inorganic colloids at a faster rate than conventional filters. This technology is put to use in many developed countries across the globe for water purification.

Nanobiocides such as MgO- and AgO-based nanoparticles can deactivate bacteria in contaminated water without generating harmful byproducts. Harmful pathogenic bacteria and viruses that cause various human ailments can also be eradicated from water using this novel technology. Polymerised nanofibrous membranes can be used for enhanced purity of water. Industry in investing lot of money in fabricating nano-based filtration systems, which are and economically feasible and commercially viable. South African researchers have gone a step ahead and have created a nano-fibre-filled water-purifying 'tea bag' that is reasonably priced and costs half a cent only. Instead of imparting flavour to the water, the bag absorbs toxins, filters out and kills bacteria, and cleans the water. This nano tea bag is portable, instantly effective, with no chance of recontamination of the environment which eludes many people. The tea bag is a simple and easy way of decontaminating small volumes of liquids, used ideally for drinking purposes.

Nano based simple water purification system for households
Source: Web

It combines ultra-thin nanoscale fibres to filter harmful contaminants, while grains of activated carbon are used to remove biological pathogens such as virulent bacteria. For use, the tea bag in placed in the neck of a water bottle to make the water flow through it for drinking. A single tea bag can clean one litre of the most polluted water. Once used, it is thrown away and a new one is inserted into the bottle neck. The nanofibres disintegrate in liquids after a few days and have no environmental impact. The raw materials of the tea-bag filter are not toxic to humans.

Although nanotechnology-based techniques have been used in water purification plants across the globe, there has been almost no development in this field in India. The technology has not yet taken off in full zeal. There is dearth of trained technical manpower in the field who can apply the knowledge at ground level. Besides, technologists are also wary about some of the possible negative effects of the nanoparticles in aquatic ecosystems. Due to their small size, their fate in ecosystems cannot be followed and understood. Once these enter ecosystems, these cannot be removed easily through the techniques available currently. How these nanoparticles will affect the vast array of living forms is something which has not been looked at by anyone. Such gaps in knowledge exist even today and these gaps can be plugged only by thorough probing and research.

Nanotechnology is going to be there and humanity is going to reap lots of benefits in future. To make that possible, interdisciplinary research is needed to answer many questions related to nanoparticles and their impact on health and environment.

Monika Koul, Assistant Professor, Department of Botany, Hans Raj College, University of Delhi, Delhi – 110007

VP at World Book Fair

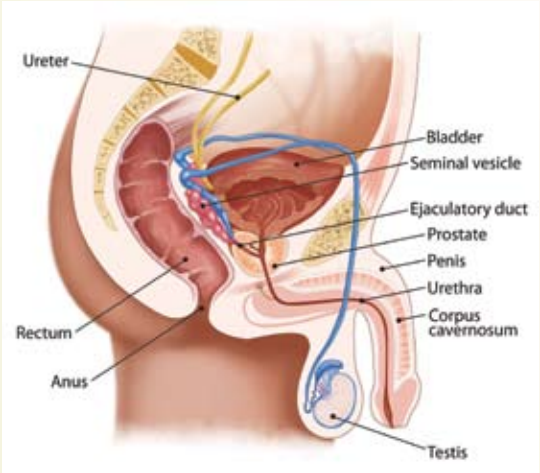
Vigyan Prasar put up stalls (Stall No. 224-225 in Hall No. 6) at the New Delhi World Book Fair (4-10 Feb 2013). Publications, software and other resource materials published and developed by the institute were displayed at the fair. Some new arrivals of VP at these stalls were Mars Beckons India, Moments in Mathematics and Tinku Ustad. During the book fair about 50,000 visitors came to VP stalls. Visitors were of the view that VP books should be made available at local levels for a wider reach. During the fair, VP also made contacts with numerous publishers-distributors to explore wider outreach of VP books and other resource materials.

Benign Prostate Enlargement—
A Common Fact of Life for Men

Dr Yatish Agarwal
e-mail: dryatish@yahoo.com

> "When the hair becomes grey and scanty, when specks of earthy matter begin to be deposited in the tunics of the artery, and when a white zone is formed at the margin of the cornea, at this same period the prostate gland usually—I might say invariably—becomes increased in size."
>
> – Sir Benjamin Collins Brodie, Celebrated 19th century surgeon, St. George's Hospital, London

The prostate is a walnut-shaped gland in men located below the bladder and in front of the rectum. It wraps around the urethra, the tube that carries urine through the penis, and secretes a milky-coloured fluid that nourishes and transports sperm out of the penis during ejaculation (orgasm). This gland undergoes many changes during the course of a man's life.



At birth, the prostate is about the size of a pea. It grows only slightly until puberty, when it begins to enlarge rapidly. It reaches normal adult size and shape, about that of a walnut, when a man is in his early 20s. The gland generally remains stable until about the mid-40s, when, in most men, the prostate begins to grow again.

By the time the life's journey is over, a large majority of men suffer the ills of prostatic enlargement. An annoying and sometimes painful problem, it is a non-cancerous condition which generally isn't life-threatening but can cause niggling urinary symptoms. Untreated, a prostate enlargement can sometimes block the flow of urine out of the bladder and can cause bladder, urinary tract or kidney problems.

With timely diagnosis, however, a prostate enlargement can often be successfully treated. Until some years ago, this necessitated going under the scalpel. That is no longer the case! Today, lifestyle changes and medications can resolve the situation in most men, although surgery always remains a good option in advanced cases.

Risk factors

The main risk factors for prostate gland enlargement include:

Aging

Prostate gland enlargement rarely causes signs and symptoms in men younger than 40. By 55, about 1 in 4 men have some signs and symptoms. By 75, about half of men report some symptoms.

Family history

Having a blood relative such as a father or brother with prostate problems means a person is more likely to have problems as well.

Identifying the symptoms

An enlarged prostate does not always cause symptoms. Only a quarter to a half of men with an enlarged prostate will have symptoms. Also, the severity of the symptoms is not always related to the size of the prostate. It depends on how much the prostate obstructs the urethra.

Some men with only slightly enlarged prostates have significant symptoms. On the other hand, some men with very enlarged prostates have only minor urinary symptoms.

As a general rule, when a prostate gland enlarges it may cause narrowing of the first part of the urethra, the tube that delivers the urine from the bladder to the outside of the body. This may partially obstruct the flow of urine.

Obstructive symptoms

When an enlarged prostate obstructs the flow of urine, you may experience a number of difficulties. These include:

Poor stream

The flow of urine is weaker, and it takes longer to empty your bladder.

Hesitancy

You may have to wait at the toilet for a while before urine starts to flow.

Dribbling

Towards the end of passing urine, the flow becomes a slow dribble.

Poor emptying

You may have a feeling of not quite emptying your bladder. You may need to strain while passing urine

Symptoms of bladder irritability

The enlarged prostate may also make the bladder irritable, which may cause:

Frequency

You may feel the need to pass urine more often than normal .This happens both during the day and night. However, it is most irritating if it happens at night. Getting up several times a night is a common symptom of prostate enlargement. It is called nocturia.

Urgency

This means you have to get to the toilet quickly when you need to go.

Factors which worsen the symptoms

A number of factors can worsen the symptoms of prostatic enlargement. These include:

- Cold weather;
- Drinking large volumes of fluids, particularly alcohol;
- Taking medicine pills such as diuretics;
- Or taking medications that may cause urinary retention, such as anti-spasmodic pills.

Course of symptoms

Usually the symptoms are mild to begin with. Perhaps a slightly reduced urine flow, or having to wait a few seconds to start passing urine. Over months or years the symptoms may become more troublesome and severe. Complications can arise in some cases.

Risk of complications

If a person neglects his prostate enlargement for long, he can run into a number of health problems. If the bladder does not empty completely, it can enlarge and make the abdomen swell visibly. When the urine stagnates, the urinary system may get infected. Also, there is an increased risk of formation of bladder stones. The complications of prostate enlargement can include:

Acute urinary retention

Acute urinary retention is a sudden, painful inability to urinate. It occurs in less than 1 in 100 men with an enlarged prostate each year. A medical emergency, this may occur especially after taking an over-the-counter decongestant medication for allergies or a cold. If this happens, you might need to immediately rush to an emergency healthcare facility.

The emergency room doctor may need to thread a tube (catheter) through the urethra (urinary passage) into the bladder. Or, he may need to put in a suprapubic tube — a catheter that drains the bladder through the lower abdomen. The choice of catheter depends on the particular circumstances. Some men with an enlarged prostate may also require surgery or other procedures to relieve urinary retention.

Urinary tract infections

Some men with an enlarged prostate end up having surgery to remove part of the prostate to prevent frequent urinary tract infections.

Bladder stones

Due to incomplete emptying of the bladder and infection, the bladder may develop mineral deposits or stones. Such stones can cause infection, bladder irritation, blood in the urine and obstruction of urine flow.

Bladder damage

This occurs when the bladder hasn't emptied completely over a long period of time. The muscular wall of the bladder stretches and weakens and no longer contracts properly. Often, symptoms of bladder damage improve after prostate surgery or other treatment, but not always.

Kidney damage

This is caused by high pressure in the bladder due to urinary retention. This high pressure can directly damage the kidneys or allow bladder infections to reach the kidneys. When an enlarged prostate causes obstruction of the kidneys, a condition called hydronephrosis — a swelling of the urine-collecting structures in one or both kidneys — may result.

When to see a doctor

If you're having urinary problems, see your doctor to check whether your symptoms are caused by an enlarged prostate and find out what tests or treatment you may need.

If you don't find urinary symptoms too bothersome and they don't pose a health threat, you may not need treatment. But you should still have your symptoms checked out by a doctor.

You could see your primary care doctor or a general surgeon, or better still, if the facilities exist, directly visit a doctor who specialises in urinary issues (urologist).

It is a good idea to be well prepared for your appointment. Write down the symptoms you're experiencing, including any that may seem unrelated to the reason for which you scheduled the appointment. Make a note of how often and when you urinate, how much liquid you drink, and if you feel you're completely emptying the bladder when you urinate. Know what tests and treatments you've had for enlarged prostate or urinary problems. For example, if you've had infections, how often have you had them and what medications worked in the past? Bring your prostate-specific antigen (PSA) test results if you've ever had your PSA checked. Write down the questions you wish to ask your doctor.

The doctor is likely to ask you a number of questions. For instance: When did you first begin noticing urinary symptoms? Have your urinary symptoms been continuous, or occasional? Have your symptoms gradually worsened over time, or did they come on suddenly? How bothersome are your symptoms? How often do you urinate during the day? How often do you need to get up at night to urinate? Do you start and stop when urinating, or feel like you have to strain to urinate? Is it difficult for you to begin urinating? Have you ever leaked urine? If so, when? Do you have a frequent or urgent need to urinate? Does it ever feel like you haven't completely emptied your bladder? Do you ever have blood in your urine? Have you had urinary tract infections? Is there any burning when you urinate? How do you know when you have a urinary tract infection? Do you have type-2 diabetes? Have you ever had any trouble getting and maintaining an erection (erectile dysfunction), or other sexual problems? What medications do you take, including any over-the-counter medications or herbal remedies? Are you on any blood thinners such as aspirin, warfarin or clopidogrel?

Each of these questions is critical from the perspective of evaluation of your condition. Based on his logical deductions, the doctor can decide upon which tests to ask for and also chart your treatment.

(*Next month*: Tests and Treatments for Prostate Enlargement) ■

Recent developments in science and technology

Biman Basu
E-mail: bimanbasu@gmail.com

Mars may have harboured life in the past

The first analysis of powder samples drilled out from the inside of once water-soaked rock indicates that Mars was a suitable place for microbial life to evolve. Analysis of Mars rocks by the *Curiosity* rover uncovered the building blocks of life – hydrogen, carbon and oxygen – and evidence that the planet could once have supported organisms. The analysis showed that water which once soaked the rock had a neutral pH – not too acidic and not too salty. Analysis of data from *Curiosity* indicates that an ancient network of rivers on Mars once made parts of the planet habitable for microbial life.

NASA's Curiosity rover drilled rock samples for a detailed chemical analysis, which point to conditions favourable for life on Mars in the distant past.

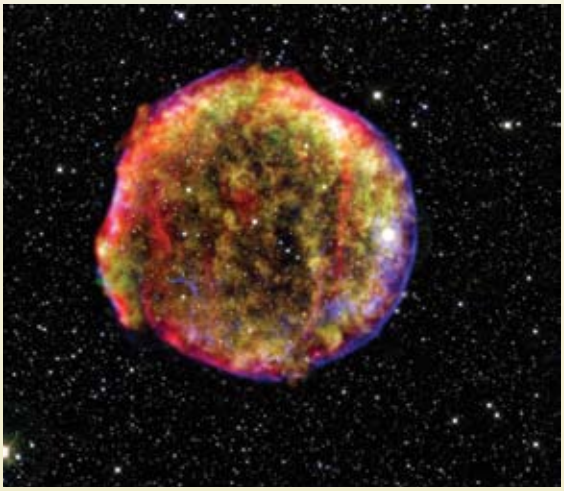
Rock dust drilled from sediments in the giant Gale crater on the red planet were found to contain clay minerals that could have formed only in water, according to NASA scientists. Clay minerals made up at least 20 per cent of the composition of this sample. *Curiosity*'s drill collected the sample at a site just a few hundred metres away from where the rover had earlier found an ancient streambed in September 2012. The discovery of other substances alongside the clays, such as calcium phosphate, suggests the soil was neutral or mildly alkaline, making the environment suitable for the growth of microbes. The rock from which the sample was collected is estimated to be at least 3 billion years old and the site's habitability period likely coincides within a couple of hundred million years of the first preserved record of life on Earth.

The nuclear-powered Mars rover *Curiosity* has been exploring an area in the basin of the Gale crater called Yellowknife Bay since its dramatic landing in August last year. Analysis of dust drilled from the bedrock found it was made from fine-grained mudstone containing clay minerals and other chemicals used by living organisms, including sulphur, nitrogen, hydrogen, oxygen, phosphorus and carbon. Clues to this habitable environment came from data returned by the rover's Sample Analysis at Mars (SAM) and Chemistry and Mineralogy (CheMin) instruments. The data indicate the Yellowknife Bay area was the end of an ancient river system or an intermittently wet lake bed that could have provided chemical energy and other favourable conditions for microbes. According to NASA scientists, the range of chemical ingredients that have been identified in the sample is impressive, and it suggests pairings such as sulphates and sulphides that indicate a possible chemical energy source for micro-organisms. Scientists plan to work with *Curiosity* in the Yellowknife Bay area for many more weeks before beginning a long drive to Gale Crater's central mound, Mount Sharp.

White dwarfs can exceed Chandrasekhar limit

More than 80 years ago, the Indian-born American astrophysicist Subrahmanyan Chandrasekhar proposed a mass limit of 1.44 times the mass of our Sun for the formation of a stable white dwarf – a faint star of enormous density formed at the end life of a moderate-size star. This limit came to be known as the 'Chandrasekhar limit'. Chandrasekhar theorised that if the mass of a white dwarf became greater than 1.44 times the solar mass it will explode as what is called a "Type 1a supernova". Chandrasekhar received the Nobel Prize in 1983 for this work. But recent research by two astrophysicists Upasana Das and Banibrata Mukhopadhyay of the Indian Institute of Science, Bangalore has shown that white dwarfs forming in extremely strong magnetic fields up to 20 trillion gauss (compared to Earth's magnetic field strength of about 0.5 gauss) could exceed the Chandrasekhar limit and grow into much bigger and brighter white dwarfs (*Physical Review Letters*, 11 February 2013 | doi:10.1103/PhysRevLett.110.071102). According to the researchers, these "super-Chandrasekhar limit" white dwarfs might occur in very high magnetic fields and such fields could stabilise a white dwarf of mass up to 2.58 solar masses.

Type-1a supernovae are formed when a stable white dwarf acquires mass by drawing matter from a companion star and exceeds the Chandrasekhar limit, which sets off a runaway thermonuclear process causing the white dwarf to explode as a supernova. According to astrophysicists, the new limit



Tycho Type-1a supernova remnant

can explain the puzzling observations during the last decade of Type-1a supernovae, which have defied explanation so far. Since 2003, astronomers have observed several bizarre Type-1a supernovae, which do not seem to conform to the conventional theoretical understanding of such objects.

Type-1a supernovae occur in binary systems (two stars orbiting one another) in which one of the stars is a white dwarf while the other can vary from a giant star or a smaller white dwarf. Type-1 supernovae can be identified by the absence of hydrogen lines in their light spectra. Due to their inherent mass limit, Type-1a supernovae were believed to explode with about the same intrinsic brightness and this fact has made astronomers use Type-1a supernovae as 'standard candles' for measuring cosmological distances. By comparing the known intrinsic brightness of a given Type-1a supernova to its observed brightness, the distance to the object can be computed using the inverse square law.

During the last 15 years astronomers have discovered a dozen or so Type-1a supernovae that are about twice as bright as the normal ones and their light curves cannot be reconciled with the conventional picture of white dwarfs with a mass limit of 1.44 solar masses. In fact, it was the observation of these extra-bright Type-1a supernovae in 1998 that led to the surprising conclusion that the expansion of the universe is actually accelerating. Astrophysicists have sought to explain this apparent acceleration of the expansion of the universe by hypothesising an unknown dark energy that fills the universe and opposes the mutual gravitational attraction of matter.

About their recent work, the researchers believe that it is too early to say whether the model has any direct implications for the expansion rate of the universe. But according them, "the existence of super-Chandrasekhar limit white dwarfs is a major paradigm shift in our understanding of white dwarfs and several of the related results may have to be examined in this light".

Distance to nearest galaxy measured accurately

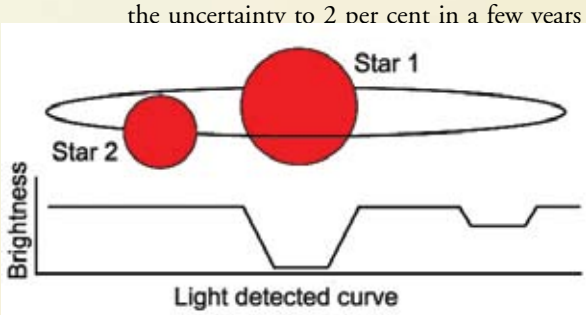
After nearly a decade of careful observations, an international team of astronomers has measured the distance to our neighbouring galaxy, the Large Magellanic Cloud (LMC), more accurately than ever before. The research was led by Grzegorz Pietrzynski of the Universidad de Concepcion in Chile and Warsaw University Observatory in Poland. This new measurement also improves our knowledge of the rate of expansion of the universe – the Hubble Constant – and is a crucial step toward understanding the nature of the mysterious dark energy that is supposed to be causing the expansion to accelerate. By careful observations of a rare class of double stars the team of astronomers has deduced the distance of the Large Magellanic Cloud to be 163,000 light-years, with an accuracy of 2.2 per cent.

The Large Magellanic Cloud

The Large Magellanic Cloud is a small irregular galaxy and our nearest neighbour galaxy. It is visible in the southern sky as a hazy patch of light. Astronomers have been trying for a hundred years to accurately measure the distance to the LMC, but without much success. The recent research, published in the journal *Nature* (7 March 2013 | doi 10.1038/nature11878), is the most precise value for the LMC distance till date. The team used telescopes at the European Southern Observatory's (ESO) La Silla Observatory in Chile and other telescopes around the world. According to the researchers, the improvement in the measurement of the distance to the LMC would help reducing the inaccuracy in current measurements of cosmological distances.

The astronomers studied rare close pairs of stars known as eclipsing binaries to work out the distance to the LMC. Eclipsing binaries are two-star systems in which the two stars orbit each other. As the two stars go round each other they pass in front of one another and their combined brightness, seen from a distance, decreases. By carefully tracking these changes in brightness and measuring the stars' orbital speeds, astronomers can work out how big the stars are, their masses, and other information about their orbits. When this is combined with careful measurements of the total brightness and colours of the stars, scientists can measure distances with extremely high accuracy.

The researchers studied eight eclipsing binaries and gathered data over eight years. Then the team was able to refine the uncertainty in the distance to the LMC down to 2.2 per cent. The astronomers hope that this new measurement can be used to reduce the uncertainty in calculations of the Hubble constant, which is a measure of the current rate of expansion of the universe, to 3 per cent. The team hopes to further reduce the uncertainty to 2 per cent in a few years as the sample of binary stars is increased. Determining the Hubble constant is critical for measuring the age and size of our universe. One of the largest uncertainties which made accurate measurements of the Hubble constant in the past involved the distance to the LMC.



Light curve of an eclipsing-binary star

Too much salt may trigger autoimmune diseases

An autoimmune disorder is a condition that occurs when the immune system mistakenly attacks and destroys healthy body tissue. There are more than 80 different types of autoimmune disorders, which include multiple sclerosis, myasthenia gravis, Graves'

Excess salt in diet may trigger autoimmune diseases

disease, rheumatoid arthritis, systemic lupus erythematosus (SLE), type-1 diabetes, and many others. Recent research shows that increased salt consumption may be a key culprit behind rising rates of autoimmune diseases. In three papers published in the journal *Nature* (6 March 2013 | doi:10.1038/nature11984, 2013, 10.1038/nature11868, 2013, and 10.1038/nature11981, 2013), researchers describe the molecular pathways that can lead to autoimmune disease and identify salt as one possible culprit.

The finding is based on work by different teams of researchers who studied the effect of salt on a kind of cells known as T_H17 cells. T- and B-cells are highly specialised cells found our immune system which protect us from infections. Different groups of these cells are tailored to different germs. When our body is infected with a particular germ, only the T- and B-cells that recognise it respond. These selected cells then quickly multiply, creating an army of identical cells to fight the infection. Special types of T- and B-cells 'remember' the invader, making us immune to a second attack.

T helper cells (T_H cells) are a sub-group of white blood cells that play an important role in the immune system. Under ordinary circumstances, T_H cells protect the body from pathogens, and each differentiated T_H cell type specialises in a different type of invader. For example, the T_H17 cells target bacteria and fungi. But some forms of T_H cells, called T_H17 cells, have been implicated in a variety of autoimmune diseases, and the researchers wanted to understand what makes harmless, immature T cells differentiate into pathogenic ones and attack the body's own cells.

In one of the published studies, immunobiologist David Hafler of the Yale School of Medicine and colleagues found that people who admitted to eating a lot of fast food harboured more T_H17 cells. It is known that fast food contains large amounts of salt. To determine whether salt accounted for the excess of T_H17 cells, Hafler and colleagues added sodium chloride to cultures of unspecialised T cells. They found that modestly raising salt concentrations, mimicking the levels in the tissues of an animal eating a high-salt diet, boosted the number of T_H17 cells that matured in the cultures nearly 10 times. And these T_H17 cells started making inflammation-provoking molecules, indicating that they had become the harmful variety.

The scientists next tested whether similar effect occurred in animals. They prompted genetically engineered mice to develop experimental autoimmune encephalomyelitis (EAE), a neurological illness similar to multiple sclerosis that is promoted by "bad" T_H17 cells. They fed some of the rodents meals that contained about as much salt as a typical fast food contains. Compared with animals that lived on low-salt food, mice that were fed high-salt diet developed EAE sooner and had more severe symptoms. Exposure to high levels of salt was found to make both cultured mouse and human T cells more pathogenic and high-salt diets worsened autoimmune disease in mice.

Another team of researchers, comprising biologist Aviv Regev of the Broad Institute in Cambridge, Massachusetts; immunologist Vijay Kuchroo of Harvard Medical School in Boston, and colleagues found that salt promotes the specialisation of T_H17 cells through an enzyme called SGK1. Knowing that SGK1 is involved in mediating salt uptake in the gut and salt reabsorption in the kidneys, the researchers decided to see what happened if they added extra salt to the cells. Not only were the salt-cultured mouse T helper cells found to be more likely to develop into T_H17 cells, but the cells that developed were also more pathogenic.

Although T_H17 cells protect us from harmful bacteria and fungi, they have also been implicated in illnesses such as inflammatory bowel disease, multiple sclerosis, and psoriasis. The recent studies suggest that salt stimulates the specialisation of these immune cells making them harmful. According to the researchers, human trials to assess effects of salt on autoimmune diseases are being planned.

Letters to editor

Taking science seriously

Let me begin by congratulating Dr. Mahanti and Dr. Gopichandran for a very remarkable publication *Dream 2047*, which I just came across in my department accidentally. I appreciate the hard work and ingenuity that is going into bringing out such a magazine. I would like receive this magazine regularly so that I can use this to motivate students with whom I come in contact towards science and its philosophy. I am of the view that scientists and academicians like us need to do much hard work to make our Indian society take science seriously, beyond its obvious potential for livelihood.

Virendra Sule
Professor
Department of Electrical Engineering
Indian Institute of Technology Bombay
Powai, Mumbai 400076, India

*****

Maths and athletic performance

I have just read the article on 'Golden ratio' (*Dream 2047* March 2013). I have been motivating students for active participation in athletics which they are good at. I have come across their casual excuse about low height being responsible for poor performance in long jump. I wondered if there was any connection between height and weight in athletic performance. This made me to link it with maths. I would like to know if there is a mathematical way to prove that height + proportionate weight = better performance in athletics/games?

K.J.Kuriyan
Principal, JPMSSS for the Blind,
C/O Blind Relief Association

*****

Golden Ratio

The two articles on Golden Ratio in Dream 2047 (March 2012 and March 2013) are quite enlightening. Set in an easy flowing conversation mode, Rintu Nath has explained a difficult concept for all levels of readership. I always read and appreciate the wealth of information every issue carries.

V. Arunachalam
Chennai.
vaiarunachalam@hotmail.com

*****