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Operation Zero

Vidyarthi Vigyan Manthan:

A national programme
to identify and nurture
scientific temper
among children
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Exploring the Space— the Final Frontier



Dr. Subodh Mahanti

Curiosity, a full-fledged laboratory (Mars Science Laboratory) safely landed on Mars on 6 August 2012. It was a great technological feat. Thousands of scientists of US space agency NASA worked over a decade for the success of the mission. The success of the mission has fired the imagination of people throughout the world. It is an astrobiology mission. It is now widely accepted that the surface of the Mars was once wet and water flowed on its surface. But then conditions changed, liquid water vanished from its surface. The planet became a dry and cold desert. However, the question whether the evolution of life ever began on Mars still remains to be resolved. The question has remained alive because of the fact that water, one of the main conditions for origin of life, existed on Mars in distant past. The main objective of sending *Curiosity* is to find out evidence of life, in whatever form, and to examine if it ever existed on Mars or whether the conditions were ever conducive for the appearance and sustenance of life. The mission will also provide other important scientific information.

Space exploration began with the launch of *Sputnik 1* on 4 October 1957. Yuri Gagarin, a Soviet pilot and cosmonaut, became the first human to go into space on 12 April 1961. Gagarin orbited the Earth for 2 hours aboard *Vostok 1*. The second human to reach the space was American astronaut John Glenn on 24 February 1962. Neil Armstrong, the American astronaut, became the first human to land on the Moon on 21 July 1969. Space stations have become a reality where astronauts live for days and months together. Unmanned spacecrafts have explored the major celestial bodies in Solar System and space exploration is continuing. A few spacecrafts have crossed the boundaries of the Solar System and have been moving towards the deep space. Space exploration is one of the most fascinating stories of human achievement in science and technology.

The idea of space travel—to escape the bounds of the Earth to explore the worlds beyond our own—has captured the imagination of human mind for ages. For centuries it remained as pure imagination and as an innate urge to fly above. Primitive humans saw birds and insects flying above effortlessly and wondered why they could not fly themselves. Many even tried to imitate birds to fly with artificial wings. Scientists and inventors took up the task of building machines for flying. In 1903, the aeroplane or the flying machine designed and built by the Wright brothers of USA made the first historic flight. Flying became a reality. However, aeroplanes could not take humans

into space.

The concept of space exploration, visiting the unknown worlds, became a favourite subject for science fiction writers. Many ended up in creating fantasies, but some of them anticipated in their unbridled imagination what were to come in future, though they were far from ground realities. Human civilisation has progressed because in every age there have been dreamers and people who translated those dreams into realities. Flying and space exploration, which remained a dream for centuries, eventually became a reality.

Science fiction writers imagined the future. They persuaded people to dream of space exploration. Some pioneers of space exploration have acknowledged that they were influenced by science fiction writers. Cyrano de Bergerac (1619-1655), a French soldier and poet, wrote the science fiction novel, *Voyage to the Moon and the Sun*. The work was published in 1657, two years after de Bergerac's death. Bergerac's hero attempted a voyage to the Moon by various artifices, which were mostly fanciful except one which used devices likened to rockets. However, he did not complete his journey by rockets as they were insufficient and so he used other methods. This was, of course, the product of imagination only. American author George Tucker (1755-1861) proposed the use of an antigravitic substance capable of neutralising gravity in his science fiction *A Voyage to the Moon*, published in 1827. The same concept was used by the English author H.G. Wells (1866-1946) in 1901 in his book *The First Man in the Moon*. The concept of a gravity-neutralising substance still remains in the realm of fantasy. French author Jules Verne (1828-1905) in his science fiction work *From the Earth to the Moon*, published in 1865, sent his heroes to the Moon by using a giant canon. The concept of a rocket was used by Achille Eyraud (1821-1882), a French writer in his book *Voyage to the Venus*, published in 1865. The idea of a manned space station was described in a science fiction story titled *The Brick Moon* by the American writer Edward Everett Hale (1822-1909), which was published in the magazine *Atlantic Monthly* in 1869.

Konstantin Tsiolkovsky (1857-1935), a Russian physicist, was the first person to discuss rocket flight into space in a truly scientific manner. In 1904, Tsiolkovsky published his prophetic study *Exploring Universal Expanses* with jet Instruments, in which he demonstrated

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Operation Zero



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I was celebrating *Holi* with my friends and relatives. It was colourful everywhere. The beautiful spectrums of colours of *gulal* made everything picturesque. It looked as if a little child played with his brushes quite liberally in his canvas.

My uncle was also in festive mood but he does not like all those colours. So he was just watching us from a distance and sometime cheering us up saying 'Attention Googol, someone is coming in this way!'

At one o'clock in the afternoon, I washed off the colours and had my bath. As I returned to drawing room, I found that my uncle was relaxing and watching television.

'So you had a nice time, Googol,' he said without taking his eyes off the television.

'Oh yes, it was very enjoying,' I replied and came near to him.

'But I did not play *Holi* with you! So I think that I can do it now,' he said, and suddenly rubbed something in my face. 'Uncle, I just had my bath and you ...' I protested.

'Cool down, dear! Check yourself in the mirror, Googol,' he said.

I realised that he had just put some talcum powder in my face.

'Don't you think that we should celebrate *Holi* with white colour only?' the question was directed at me.

'I could not get that,' I said.

'What physics say...,' he implied.

'Oh yes, white colour is the mixture of all colours,' I said and spread the powder over my face.

'Right, so the festival of colours will be really meaningful with white colour,' he added.

'I got that. That means if I put black colour in your face, actually I will not put any colour,' I quipped, 'you know, physics say that...'

'You naughty boy!' smiled uncle.

'So before putting forward your suggestion on real colourful *Holi*, we have to prepare being painted with *nothing* in our face from scientifically inclined persons,' I said.

'Well, I admit,' uncle said, 'but while dealing with *nothing* in mathematical world,

you should be more cautious.'

'Yes, I remember, you earlier told me about the problems related with operation of zero. Could you please clarify more?' I was very eager to hear the next part of story and so I drew myself closer to him.

'Well, do you know about real numbers?' uncle asked.

'Real numbers consist all rational (i.e. the numbers which can be express as p/q , like 2) and irrational numbers (which cannot be expressed as fraction, like $\sqrt{2}$),' I said.

'Right. Now all these real numbers can be placed uniquely in a real line towards both positive and negative direction. Hence all positive, negative, even, odd, rational and irrational numbers correspond to only a single point on the line,' uncle explained.

I nodded my head understanding the real line principle.

'Could you now tell me, where zero stands in this real line?' uncle asked me.

'It seems that it is just standing as borderline between the positive and negative numbers,' I replied.

'Yes, among these real numbers, zero has the most important and unique position. It is in the intersection between positive and negative numbers. If you go to the right side from zero, it is positive numbers and if you go towards the left side of zero, it is all negative numbers. So essentially zero is neither positive nor negative number, it is the borderline for positive and negative numbers, or it is neutral in that sense. In fact this is the only number in the real number world, that is neither positive nor negative.'

'So zero is a lonely person standing in the borderline with nobody around it to share its characteristics – even 1 is not such a lonely number,' I joked.

'To be precise, zero as single entity has no power of its own. Even if you put the poor fellow to the left side of any number (without any decimal), still it is powerless. But if you start adding it to the right side of a number, then zero starts showing its power and the number increases by ten times for each addition.'

'So a lonely and tiny person can be real powerful depending on the situation. But does zero share any feature of an odd or

even number?' I questioned.

'Well, simply speaking an even numbers are those which are divisible by 2 and odd numbers are those that are not divisible by 2. Since theoretically zero is divisible by 2, so zero is considered to be even number. But many people do not consider zero as even number since zero is divisible by any number irrespective of positive and negative and divisibility with 2 is not very unique feature to zero as that of other even numbers.'

'What about zero as prime number?' I got interest in the discussion.

'A prime number is a positive integer that has no positive integer divisors other than 1 and the number itself. So by definition, prime number is a positive integer and should be placed in the right hand side of 1 in our real line scale. Clearly zero does not fit in this definition and so zero is not a prime number.'

'I can understand now that Brahmagupta might have to give a lot of thinking to define zero in a number system and to present the rules for its operation. I can remember that he correctly defined the position of zero in the number system and gave the rules of addition, subtraction and multiplication.' 'You are absolutely right. If we add zero with a positive and negative number, then we will remain in the same number point in the real line scale. And if we multiply any positive and negative real number with zero, then we will be directed straight to the position zero.'

'And what about the division by zero?' I asked.

'Well, the division by zero is a tricky one. Brahmagupta himself could not describe the operation properly and later Bhaskara also mentioned it incorrectly.'

'I can remember what Bhaskara said: if any number is divided by zero, it is infinity.'

'Well, at first instance, assigning some positive number divided by zero as

infinity or very high value, seems logical. For example, if you continue to divide a real positive number by a smaller number, then your result will go on increasing. Like:

$$\begin{aligned} 10/10 &= 1 \\ 10/1 &= 10 \\ 10/0.01 &= 1000 \\ 10/0.0001 &= 10,0000 \\ &\vdots \\ &\vdots \\ 10/10^{-99} &= 10^{100} \\ &\text{and so on} \end{aligned}$$

‘So when we will divide the number by zero, it will go towards infinity or a very very high value,’ I said.

‘Well, as you divide by a smaller number and go towards zero, the result increases. But remember, still the smaller number is not equal to zero. Therefore, you are *not* actually doing any division by zero, rather you are predicting a trend, which might be possible if divisor reaches a value, closer to zero or very small numbers. But whatever the smallest number you can think of, another number smaller than that exists. Moreover, you should remember that infinity is a concept, an abstract thing, not a number as defined in our number system and all rules of mathematics are invalid while you will consider operation with infinity. Like if you add infinity and infinity you will not get twice the value of infinity. It is still infinity!’

‘Then it is wrong to say that a number divided by zero is infinity,’ I said.

‘Exactly! In fact, in the very first place it is wrong to attempt to divide a number by zero,’ uncle emphasized.

‘So what should be the actual explanation for this situation?’ I was curious.

‘Well, let me give you a further clarification. A division is essentially the inverse of multiplication rule. That means if you divide 10 by 2, then you will get 5. And if you multiply 5 with 2, then you will get your original value back again. Through algebra, we can put it like this:

$$\text{If } (a/b) = c, \text{ then } a = (b * c)$$

Let’s see what will happen if we follow the infinity theory. Assume that $a = 10$ and $b = 0$. Now, if you attempt to do (a/b) and assume $c = \text{infinity}$, then according to rule of multiplication, we get $10 = (0 * \text{infinity})$. But the rule of multiplication for zero says that anything multiplied with zero is zero.

That means, applying the multiplication rule in right hand side gives us finally: $10 = 0$. So you cannot get back 10 by multiplying the elements in the right hand side, rather you will get some absurd result as above while attempting and evaluating something divided by zero.’

‘So we should not divide a number by zero...’

‘Yes! The uniqueness of division breaks down when you attempt to divide any number by zero since you cannot recover the original number by the inverting the process of multiplication. And zero is the only number with this property and so division by zero is *undefined* for real numbers. So you should *never* attempt to do a division with zero. In fact, it is meaningless to attempt to do this operation.’

‘Ok, I should not attempt to do any mathematical operation related with division by zero since it is not even defined in our mathematical world.’

‘Let me give you another very common example to show what could happen if you ever try to attempt to do something like that.

$$\text{Let, } x = y$$

Multiplying both side by y , we get,

$$x * y = y * y$$

If we subtract y^2 from both side, then it becomes:

$$x * y - y^2 = y * y - y^2$$

This can be written as

$$x * y - y^2 = y^2 - y^2$$

With some simple algebra, the expression becomes:

$$y * (x - y) = (y + y) * (y - y)$$

Since we have assumed, $x = y$, so we can write: $y (y - y) = (y + y) * (y - y)$

Now if we divide both side by $(y - y)$, then it comes as: $y = 2y$

Or if we cancel out y from both sides, it is $1 = 2$.

Ok Googol, tell me now why does this type of meaningless result come after doing all those seemingly legal algebraic operation?’

‘I think that the cancelling out $(y - y)$ is not the correct method...’

‘Right! You can see that we are actually cancelling out $(y - y)$ from both side, which actually equals to zero and legally we cannot do the simple division with zero and if you do, it will make thousands of mathematical rules invalid. Simply speaking, there is no

Undefined

In mathematics, an expression is said to be **undefined** which does not have meaning and so that is not assigned an interpretation. For example, division by zero is **undefined** in the field of real numbers.

Indeterminate

A mathematical expression is said to be **indeterminate** if it is not definitively or precisely determined. Certain expressions of limits are termed as **indeterminate** in limit theorem. There are seven indeterminate forms involving 0, 1 and infinity (∞).

$$(0 / 0), 0 \cdot \infty, (\infty / \infty), (\infty - \infty), 0^0, \infty^0, 1^\infty$$

Vanishing

A function, which takes the value zero for a particular set of points, is said to **vanish** for that set of points. For example, in the function $y = x^2$, the value of y will vanish in points where $x = 0$. Sometime the term, **vanish identically** is used in the same perspective to denote that the function takes the value which is mathematically identical and equal to zero.

Non-vanishing

A function, which takes the non-zero values for all sets of points, is said to **non-vanishing**. For example, in the function $y = (x^2 + 1)$, the value of y will be non-vanishing for real values of x .

Identically Zero

Sometime, to put it sufficiently strongly, a quantity that rigorously assumes the value of zero is said to be **identically zero**. A quantity that is identically zero is said to be **vanishing**, or sometimes to **vanish identically** as mentioned above.

Zero free

An integer value whose digits contain no zeros is said to be **zero free**. For example, square of 334 is a zero free square. In recent times a lot of interesting works are going on to find the **zero free** number for n^{th} power.

Absolute Zero

Absolute zero is the temperature when there is no movement of molecules. The measurement of temperature cannot go lower than this and this is shown in Kelvin scale as zero. The **absolute zero** is equivalent to -273 degree Celsius.

number in real number world, which equals to the expression: x divided by zero.'

'Now I can understand, that is why the division by zero is made *undefined* in mathematical terminology so that if we follow this simple single rule then we don't have to worry about thousands of other mathematical rules which will be valid always.'

'Yes! This is the reason that in all computer programs or mathematical calculations, one should take care of this vital operation and there should have appropriate strategy to deal with this situation. Imagine, a remotely controlled rocket is going towards a distant star and the computer installed in it, is doing millions of vital calculation every second. But the scientists who programmed the computer just inadvertently forgot to tell the computer what it should do if something like division by zero occurs. And unfortunately if it occurs, the computer will stop working and it will wonder what to do with this undefined operation. So all the efforts of the scientists will be a waste! Zero is so powerful.'

'I have seen that if I try to do the division by zero in calculator it shows 'E'.'

'Right. This means the operation you are attempting is erroneous and you should not attempt this operation.'

'Ok, so something divided by zero is undefined and it is wrong to do any operation involving that. Is this rule only applicable to real numbers?'

'Well, this is true for the world of real numbers. But in calculus theorem, limits involving division by a real quantity, which approaches zero, may be well-defined. For example, you will get the expression like this: *limit x tends to zero* ($\sin x / x$) equals to 1, i.e. $\lim_{x \rightarrow 0} \left(\frac{\sin x}{x} \right) = 1$. But be careful, our concept of something divided by zero as undefined still holds good, since in above function you are *not* attempting any value of x which is equal to zero. For the same reason limits like *limit x tends to zero* ($1 / x$) i.e. $\lim_{x \rightarrow 0} \left(\frac{1}{x} \right)$ do not exist.'

'When it is so critical phenomenon with something divided by zero, I wonder what about zero divided by zero?'

'Well, this is another interesting case. Mathematically speaking, an expression like zero divided by zero is called *indeterminate*. To put it simply, this is a sort of expression, which cannot be determined accurately. If

you see the expression properly, you can't assign any value to it. That means $(0 / 0)$ can be equal to 10, 100 or anything else and interestingly the rule of multiplication also holds true here since 10 or 100 multiplied by zero will give the product as zero. So the basic problem is that we cannot determine the exact or precise value for this expression. That's why mathematically $(0 / 0)$ is said to be *indeterminate*.'

'It's amazing! It is now understandable that why our forefathers had the problem in defining operations involved with zero. They have done really a great job. I remember, Bhaskara has also given the correct rule for square of zero.' 'Yes. The square of zero is similar in meaning to multiplying zero two times. So according to multiplication rule, it should be zero. It is not only square, but cube and all powers of zero is zero.'

'And what about the square root of zero?'

'Similar to square or cube of zero, the square root, cube root, fourth root and so on all will be zero. You can easily get the logic if you think that the square root of zero should be such a number, which if multiplied twice should give you zero. Or in other way, square root is nothing but taking $\frac{1}{2}$ as power and so all powers of zero are equal to zero.'

'And what will happen if I make zero as a power to some number?'

'Well, if you put zero as power to any number, it is always one. This comes from the rules by which we deal with operations involved with powers. For example:

$$x^2 = x * x$$

$$x^{-2} = 1 / x^2 = 1 / (x * x)$$

Hence, x^0 can be written something like: x^{2-2}

$$\text{Which we can separate as: } x^2 * x^{-2}$$

This gives us: x^2 / x^2 , which makes our result as 1.'

'What about zero to the power zero?'

'Mathematically, this situation is similar to zero divided by zero. Using limit theorem, it can be found that as x and a tend to zero, the function a^x takes values between 0 and 1 inclusive. So zero to the power zero is also termed as *indeterminate*. But modern day mathematicians are giving many new theories and insights regarding proper explanation of zero to the power zero. Some mathematicians say that accepting $0^0 = 1$ allows some formulas to be expressed simply while some others point out that $0^0 = 0$

makes the life more easier. So this expression is not as naïve as it looks like!'

'Now I know about two indeterminate forms in mathematics. The first one is $(0 / 0)$ and the second is 0^0 . Is there any other indeterminate form involving zero?'

'Well, to be precise there are seven indeterminate forms in mathematics involving 0, 1 and infinity.'

'I have recently did many permutations and combinations during World Cup matches. So I feel curious to know about the factorial zero.'

'The factorial of zero is equal to one. This is because the number of permutations you can do with zero elements is only one. This also can be proved mathematically. Remember here that the factorial of one is also one.'

'Uncle, frankly speaking I have discovered zero today in completely different perspective. Till now I used to think that zero is a tiny number and makes everything easy while it appears in calculations. But now I can understand that this tiny number zero could give mathematicians in the world so many troubles. Hence whenever it is operation with zero, it should always be handled with care and caution. Am I right?'

'Yes, you are absolutely right! Zero is tiny number, but you should never ignore its might. Imagine the world without zero. Not only mathematics, but all branches of sciences would have struggled for more clear definitions in their individual contexts, had zero not exist in our number system. Numbers from 2 to 9 are absent in binary system, and so are 8 and 9 in octal system. However, zero is everywhere and it is one of the significant discoveries of mankind. Thanks to the ingenuity of our forefathers.'

'I think that if any organization codes a task as *Operation Zero* then we can presume it may not be a simple task at all...'

'Yes, it should be really the most difficult task since mathematics presume that the task involve many undefined and indeterminate operations!'

'Uncle, I have an idea. To extend our analogy of numbers with colours, it seems more appropriate to assign zero as black colour. They are physically nothing, but both of them have tremendous impact while you see them with other colours or numbers.'

'That's a good analogy, Googol! Put your imagination in motion...'

It's a Higgs boson!

But certainly not the God particle!

“We have a discovery”

On 4 July 2012, physicists working at the European Organization for Nuclear Research (CERN), Geneva, the world's biggest laboratory for particle physics, announced the discovery of the Higgs boson, a particle hotly sought after by theoretical high energy physicists for nearly forty-eight years. “We have a discovery”, Rolf Heuer, the Director General of CERN was in no doubt. The results were presented by Joe Incandela and Fabiola Gianotti, the leaders of the two experiments CMS and ATLAS respectively; fitted to the Large Hadron Collider (LHC) looking for the elusive particle. Both the experiments found its mass to be around 125 giga-electron-volts, or about 131 times the mass of the proton. The discovery apparently provides the finishing touch to the Standard Model that till date remains the best explanation of how the universe works, except in the domain of gravity. Gravity is governed by the General Theory of Relativity. The next step would be to ascertain if the observed particle is really the Higgs boson the scientists were looking for in the Standards Model, or if it is an exotic creature belonging to a different domain. If it turns out to be an exotic particle, it may prove to be the beginning of the undoing of the Standard Model itself, and its replacement by a better theory. In either case, may be, we are one step closer to understanding the universe, it seems.

What is a Higgs boson? Why it is so important? Why are the particle physicists the world over so excited about its discovery? To give an analogy, particle physics is to universe what DNA is to life, or what Newton's laws are to physics. Like the discovery of the DNA structure in 1953 that shed new light on the life processes and helped us understand them better, the Higgs boson helps us comprehend the universe better. Without the Higgs, there

would be no mass. For sure, without mass there would be no atoms, no planets, no stars and no galaxies. And there would be no



Cern announcement

plants, animals, nor human beings! Massless particles would travel at the speed of light following the diktats of Einstein's theory of relativity; and they would continue to do so for ever. They would have no past, present or future. Higgs particle gives us mass, and

with (classified as fermions) and the particles that transmit the forces (classified as bosons after Satyendra Nath Bose who proposed them (see Box 2).

As it turns out, there are only 17 particles in the Standard Model. Of these, 6 are *fermions* such as quarks that make up neutrons and protons in nuclei; and 6 *leptons* (“light” particles) such as electrons that go around these nuclei. Quarks and leptons are the particles that make up the matter. Four particles are called ‘gauge bosons’. These are the particles that transmit forces and thus allow fermions to interact. The Higgs boson is *not* a gauge boson. It is required not to transmit force, but to give mass to other particles. But, before we continue with the story, let us describe the Standard Model and why it is important

not only to particle physicists, but also for everyone and everything we come across in nature.

The Standard Model as it stands

The Standard Model is a theory concerning the three fundamental interactions called the electromagnetic, strong, and weak nuclear interactions that mediate between



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Box 1: The God particle?

Nobel laureate Leon Lederman, a Fermilab physicist, wrote a book in the early 1990s about particle physics and the search for the Higgs boson. His publisher coined the name as a marketable title for the book. Scientists dislike the nickname. Lederman jokes that he actually wanted to call the particle “The Goddamn particle” because it is so difficult to find! The name “The God particle” is certainly suited for catchy headlines, but most particle physicists feel a disdain for it. This is not just one Higgs boson that is predicted, and that is not the end of the story anyway. Supersymmetry predicts a family of these particles! “It was a joke, not to be taken seriously”, said Peter Higgs during a recent interview to *New Scientist*.



hence we are here. Its import is ‘massive’ indeed! This is why it is popularly referred to as the God particle, which certainly it is not (See Box 1).

What are we are made of? Just a few particles!

Today we know that molecules are made of atoms. Atoms are made of particles called protons, neutrons, and electrons. Protons

Interactions in physics are the ways in which particles influence other particles. At macroscopic level, electromagnetism allows particles to interact with one another via electric and magnetic fields. The Standard Model explains such forces as resulting from matter particles exchanging other mediating particles, known as 'force mediating particles'. When a force-mediating particle is exchanged between two particles, at a macroscopic level the effect is equivalent to a force influencing both of them, and the particle is therefore said to have 'mediated' that force. Photons mediate the electromagnetic force between electrically charged particles. The photon is massless. The Z^0 , W^+ and W^- gauge bosons have non-zero mass and yet mediate the weak interactions between all quarks and leptons. They are massive, with the Z^0 being more massive than the W^+ and W^- . The gluons mediate the strong interaction between the quarks. Gluons are massless. The gauge bosons of the Standard Model all have spin 1, thus making them bosons.

Finally, we come to the Higgs boson shown separately. Higgs is *not* a gauge boson. Physicists do not need it to transmit force, but to give mass to other particles. Two of the 16 other fundamental particles, the photon and the gluon, are massless. But without the Higgs, there is no explanation of where the mass of other particles comes from. Apparently this appears to be the particle announced by CERN on 4 July 2012, properties of which need to be further investigated to establish if this is indeed the Higgs particle as required by the Standard Model.

We may note that the 17 particles we have described here are the basic particles of the Standard Model. We also must note that every fundamental particle has an antiparticle which carries an electric charge that is opposite of the charge on the particle. Thus we have six quarks and six antiquarks; and six leptons and six antileptons. As regards the bosons – photon, gluon, Z^0 , and the Higgs Boson (H^0) are their own antiparticles, while antiparticle of W^- is W^+ . They are responsible for some 200 composite particles (protons, neutrons, mesons, etc.) that we observe in various circumstances through different combinations and at different energies. If we include graviton (spin 2 and

hence a boson) which is supposed to be the carrier of gravitational interaction and its own antiparticle, though not included in the list of the Standard Model, the total number of the fundamental particles thus would add up to 31.

The fundamental particles described above and others that are composed by various combinations of these particles are classified into several groups depending on their properties. For example, hadrons (heavy particles) include mesons (kaons, pions, etc.) which are bosons; and baryons which include protons, neutrons and other

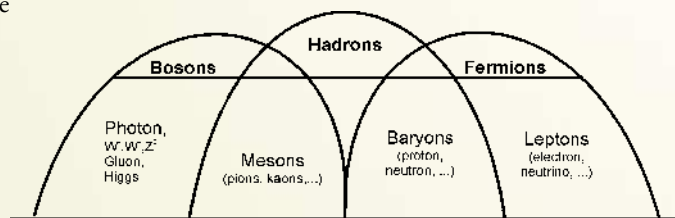


Figure 2: Particle classification. Note that mesons are bosons and hadrons; and baryons are hadrons and fermions.

heavy particles that are fermions. These are schematically depicted in Figure 2.

How the Higgs boson was postulated

By 1930s, it became clear that the ranges of the fundamental forces would be inversely proportional to the masses of the particles that transmit force. These, incidentally, can be regarded as the quantum excitations of the all-pervasive force fields. For example, photon is an excitation of the electromagnetic field. Hence, barring the massless photon (which transmits the electromagnetic force), the carriers of strong and weak nuclear forces need to be massive particles. Now, symmetry of equations of electromagnetism makes photon massless, making electromagnetic force have an infinite range. When this idea was extended to strong and weak interactions, the extended symmetry operation implied that the excitations of these force fields when included in the theory should also be massless! Thus the symmetry required that the matter particles in the theory – quarks and leptons – should also be massless.

In 1964, Peter Higgs and other particle physicists came up with a solution. They demonstrated that

by introducing a “scalar field” (whose particles have zero value for quantum spin) and incorporating the mechanism of so-called “spontaneous symmetry breaking”, the problem of massless particles could be solved in theories with gauge invariance as the underlying mathematical symmetry. In physics, gauge invariance (also called gauge symmetry) is the property of a field theory in which different configurations of the underlying fields – which are not themselves directly observable – result in identical observable quantities. A theory with such a property is called a gauge theory.

A transformation from one such field configuration to another is called a gauge transformation. The Higgs mechanism when incorporated into the field equations, would *allow particles to have masses*. The other physicists who independently came up with the mechanism were Francois Englert and Robert Brout; and Gerald Guralnik, C. R. Hagen, and T.W.B Kibble. This however, came to be known as the Higgs mechanism.

The foundations of the Standard Model, as we know today, were first laid in the late 1960s when Steven Weinberg, Abdus Salam, and Sheldon Glashow showed that by incorporating a Higgs field into a field theory with generalised gauge invariance one could *unify* electromagnetism and the weak nuclear force in a single mathematical framework and with appropriate masses for the weak force carriers (W and Z bosons) and the fermions in the theory, in accordance with the observations. Such a theory described electromagnetism and the weak force as manifestations of a single force called the electroweak force. Thus, inclusion of the Higgs field allows most of these elementary particles to have masses. For example, if the electron had no mass, there would be no atoms!

Integrating Higgs mechanism into the Standard Model allowed scientists to make predictions of various quantities, including the mass of the heaviest known particle, the top quark. Experimentalists found this particle just where equations using the Higgs mechanism predicted it should be. The Higgs mechanism works as a medium that exists everywhere in space. Particles gain mass by interacting with this



Peter Higgs



Large Hadron Collider (LHC)

medium. Peter Higgs pointed out that the mechanism required the existence of an unseen particle, which we now call the Higgs boson. The Higgs boson is the fundamental component of the Higgs medium, much as

the photon is the fundamental component of light. The Higgs boson gets its mass from the self-interaction in the Higgs field, which arises through a mechanism known as “spontaneous symmetry breaking” by the Higgs field of a

certain universal symmetry that prevailed at the time of Big Bang. The Higgs mechanism does not predict the mass of the Higgs boson itself but rather a range of masses. Fortunately, the Higgs boson when it decays would leave a unique particle footprint depending on its mass. So it would be possible for scientists to know what to look for and they would be able to calculate its mass from the particles they saw in the detector.

(To be continued)...

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Continued from page 35 (Exploring the Space—the Final Frontier)

the possibility of using jets to fly into space. He also discussed the possibility of constructing a space station. He said: “We have the ability to build a permanent observatory moving around the Earth for a long, indefinite time beyond the limits of the atmosphere, just like our Moon.” A revised and updated version of the work was brought out in 1912. Tsiolkovsky believed that permanent human settlement beyond the Earth was a necessity. He thought: “The Earth is the cradle of mankind. But man cannot live in the cradle forever.” The film *Space Voyage* was based on Tsiolkovsky’s ideas. The German scientist Hermann Oberth’s (1894-1989) book *The Rocket in Interplanetary Space* is a milestone in space science, which was published in 1923. Oberth was a great inspiration in space science.

The invention of the rocket made it possible to launch spacecrafts. Rockets in their earliest forms were first used in warfare by Chinese in 1232. In India, Tipu Sultan (1751-1799) used rockets against the British. William Congreve (1772-1828), a British artillery officer, improved the rockets used by Tipu Sultan further. These rockets were very small compared to the rockets used in space flights. Tsiolkovsky not only designed rockets but also suggested the type of fuel to be used. He thought the best fuel would be a mixture of hydrogen and oxygen. He described for the first time the multi-stage rocket. However, Tsiolkovsky did not try to put his ideas into practice. It was Robert Hutchings Goddard (1882-1945), an American professor, physicist and inventor who launched the world’s first liquid fuel rocket on 16 March 1926. Goddard’s monograph titled *A Method of Reaching Extreme Altitudes* published in 1920 is considered as one of the fundamental classics of rocketry. However, at the time of its publication it was not taken seriously. In fact, America’s leading newspaper *The New York Times* ridiculed Goddard for his impossible vision of launching a rocket that could travel through space in vacuum. The newspaper issued a public apology to the late Goddard after *Apollo* astronauts took off for the first lunar landing.

Oberth’s student Wernher von Braun (1912-1977) a German-born rocket scientist led the group which constructed the V-2, the first guided missile in history, during the Second World War. Von Braun later migrated to the USA where he guided the project for development of giant space rocket Saturn V, which was used by

NASA for launching humans to the Moon. Space exploration became a reality because thousands of scientists worked for decades.

It is true that in-born spirit of enquiry has taken human beings from known to the unknown. So it is natural that human beings have ventured into space, being the ultimate frontier. The other reason for exploration of space is to search for life. Our present understanding of the laws of the universe tells us that the Earth on which we evolved will not remain habitable forever. It is true the Earth will continue to sustain human existence for a long time to come. It may be thousands or millions of years. Exploration of space should be viewed not simply because of our exploratory zeal or search for life, but for more practical reason imaginable—to ensure the existence of human beings beyond the span of Earth’s capacity to sustain life. Human beings may have to move from Earth to the distant worlds of the Solar System and then finally move towards the distant stars. Even before the situation arises where humans will have to move out of the Earth they may require resources from outer worlds. This scenario was once described by Tsiolkovsky. He wrote: “Men are weak now, and yet they transform the Earth’s surface. In millions of years their might will increase to the extent that they will change the surface of the Earth, its oceans, the atmosphere, and themselves. They will control the climate and the Solar System just as they control the Earth. They will travel beyond the limits of our planetary system; they will reach other Suns, and use their fresh energy instead of the energy of their dying luminary.”

We cannot say at this stage whether it will take millions of year to realise what Tsiolkovsky dreamt of, or it will be realised much earlier, or it will be never realised. Today we can only imagine how it can be achieved. In the meantime science fiction writers will continue to depict many imaginary possibilities. There is no doubt, as in the past, future science fiction writers will inspire many to take up the challenges. Scientists will continue to build up their expertise. Today’s dreams will be tomorrow’s realities. As Charles A. Lindbergh (1902-1974) an American aviator and author had said, “We live in a world where dreams and reality interchange.”

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Brain Stroke

Medications, Treatments and Outcome



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Ah, Hope! What would life be, stripped of thy encouraging smiles, that teach us to look behind the dark clouds of to-day, for the golden beams that are to gild the morrow.

—Susanna Moodie, *Life in the Clearing*

Emergency treatment for stroke depends on whether a person has had an ischaemic stroke blocking an artery — the most common kind — or a haemorrhagic stroke involving bleeding into the brain.

Ischaemic stroke

To treat an ischaemic stroke, doctors must quickly restore blood flow to the brain.

Emergency treatment with medications

Therapy with clot-busting drugs must start within 4.5 hours — and the sooner, the better. Quick treatment not only improves the chances of survival, but may also reduce the complications from stroke. The following medications may benefit a victim of ischaemic stroke:

Aspirin

Aspirin is the best-proven immediate treatment after an ischaemic stroke. Most significantly, it helps reduce the likelihood of having another stroke.

The dose may vary, but if a person is already taking a daily aspirin for its blood-thinning effect, s/he may want to make a note of that on an emergency medical card so that the doctors will know that s/he has already had some aspirin.

Other blood-thinning drugs, such as warfarin, heparin and clopidogrel also may be given, but they aren't used as commonly as aspirin for emergency treatment.

Intravenous injection of tissue plasminogen activator (TPA)

Some people who are having an ischaemic stroke can benefit from an injection of tissue plasminogen activator (TPA), usually given through a vein in the arm. TPA is a potent clot-busting drug that helps some people who have had a stroke recover more fully. However, intravenous TPA can be given only within a 4.5-hour window of the stroke occurring. TPA involves certain risks that the doctors will consider in assessing whether it is the right treatment for a given person. TPA cannot be given to people who are having a haemorrhagic stroke.



Emergency procedures

Doctors sometimes treat ischaemic strokes with procedures that must be performed as soon as possible.

TPA delivered directly to the brain

Doctors may thread a catheter through an artery in the groin up to the brain, and then release TPA directly into the area where the stroke is under way. The time window for this treatment is somewhat longer than for intravenous TPA but still limited.

Mechanical clot removal

Doctors may also use a catheter to manoeuvre a tiny device into the brain to physically grab and remove the clot.

Other procedures

To reduce the risk of having another stroke or TIA, the treating doctor may recommend a procedure to open up an artery that's moderately to severely narrowed by plaques. Doctors also sometimes recommend these procedures to prevent a stroke.

Options may include:

Carotid endarterectomy

In this procedure, a surgeon removes plaques blocking the carotid arteries that run up both sides of the neck to the brain. The blocked artery is opened, the plaques are removed and the surgeon closes the artery. The procedure may reduce the risk of ischaemic stroke. However, in addition to the usual risks associated with any surgery, a carotid endarterectomy itself can also trigger a stroke or heart attack by releasing a blood clot or fatty debris. Surgeons attempt to reduce this risk by placing filters (distal protection devices) at strategic points in the bloodstream to "catch" any material that may break free during the procedure.

Angioplasty and stents

Angioplasty is another technique that can widen the inside of a plaque-coated artery leading to the brain, usually the carotid artery. In this procedure, a balloon-tipped catheter is manoeuvred into the obstructed area of the artery. The balloon is inflated, compressing the plaques against the artery walls. A metallic mesh tube (stent) is usually left in the artery to prevent recurrent narrowing. Inserting a stent in a brain artery (intracranial stenting) is similar to stenting the carotid arteries. Using a small incision in



the groin, doctors thread a catheter through the arteries and into the brain. Sometimes they use angioplasty to widen the affected area first; in other cases, angioplasty is not used before stent placement.

Haemorrhagic stroke

Emergency treatment of haemorrhagic stroke focuses on controlling bleeding and reducing pressure in the brain. Surgery may also be used to help control future risk.

Emergency measures

If a person has been taking warfarin or antiplatelet drugs such as clopidogrel to prevent blood clots, s/he may be given drugs or transfusions of blood products to counteract their effects. S/he may also be given drugs to lower the blood pressure, prevent seizures or reduce the brain's reaction to the bleeding (vasospasm). People having a haemorrhagic stroke can't be given clot-busters such as aspirin and TPA because these drugs may worsen bleeding.

Once the bleeding in the brain stops, treatment usually involves bed rest and supportive medical care while the body absorbs the blood. Healing is similar to what happens while a bad bruise goes away. If the area of bleeding is large, surgery may be used in certain cases to remove the blood and relieve pressure on the brain.

Surgical blood vessel repair

Surgery may be used to repair certain blood vessel abnormalities associated with haemorrhagic strokes. The treating doctor may recommend one of these procedures after a stroke or if a person is at high risk of spontaneous aneurysm or arteriovenous malformation (AVM) rupture:

Aneurysm clipping

A tiny clamp is placed at the base of the aneurysm, isolating it from the circulation of the artery to which it is attached. This can keep the aneurysm from bursting, or it can prevent re-bleeding of an aneurysm that has recently haemorrhaged. The clip will stay in place permanently.

Coiling (aneurysm embolisation)

This procedure offers an alternative to clipping for certain aneurysms. Surgeons use a catheter to manoeuvre a tiny coil into the aneurysm. The coil provides a scaffolding where a blood clot can form and seal off the aneurysm from connecting arteries.

Surgical AVM removal

It is not always possible to remove an arteriovenous malformation if it is too large or if it is located deep within the brain. Surgical removal of a smaller arteriovenous malformation from a more accessible portion of the brain, though, can eliminate the risk of rupture, lowering the overall risk of haemorrhagic stroke.

Stroke recovery and rehabilitation

Once the best possible emergency treatment has been given, stroke care focuses on helping the sufferer regain his strength, recover as much function as possible and return to independent living. The impact of a stroke depends on the area of the brain involved and the amount of tissue damaged. Harm to the right side of the brain may affect movement and sensation on the left side of the body.

Damage to brain tissue on the left side may affect movement on the right side; this damage may also cause speech and language disorders. In addition, a stroke victim may have problems with breathing, swallowing, balancing and hearing. S/he may also experience loss of vision and loss of bladder or bowel function.

Most stroke survivors receive treatment in a rehabilitation programme. Doctors will recommend the most rigorous rehabilitation programme a person can handle based on his/her age, overall health and degree of disability from stroke. The recommendation will also take into account a person's lifestyle, interests and priorities, and availability of family members or other caregivers.

The rehabilitation programme may begin before a person leaves the hospital. It may continue in a rehabilitation unit of the same hospital, another rehabilitation unit or skilled nursing facility, an outpatient unit, or a person's home.

The medical care team

Every person's stroke recovery is different. Depending on the complications, the medical team of experts who help in recovery could include a neurologist, a rehabilitation doctor (physiatrist), nurse, dietician, physical therapist, occupational therapist, speech therapist, and a psychologist or psychiatrist.

Nursing care is a high priority till a patient makes a good recovery. It is important to move the patient regularly to avoid bed sores, to position the patient appropriately, and to move the joints to avoid permanent stiffening.

After two weeks, physiotherapists start to take a much more active role in helping recovery and they also try to prevent the patient developing wrong habits. As patients improve, some muscle movements tend to recover more quickly than others. Bad posturing can result, and this hinders improved function in the long run. The ability of the muscles to contract increases, which may mean that they become so stiff they prevent full joint movement. This is kept under check by a carefully tailored recovery plan suited to the individual requirements of a patient.

On the course to recovery

In many patients the physical illness of stroke is past at two weeks. Many patients will be improving daily. In others, however, serious paralysis or other neurological deficits will persist and if they are left with some disability they will have to learn to cope with it. There isn't much point in keeping a patient in the hospital. The recovery can occur at a faster or an equally good rate at home if due care is provided.

Looking ahead

Going by a progress a patient makes, the doctor may have a good idea of how recovery is going to proceed. When the patient's hand is affected, for example, but he can move his fingers and thumb at two weeks, the doctor can be optimistic that the hand will recover well. If there is no sign of finger movement and very limited movement at the shoulder and elbow, it is very likely that the hand and arm may only be useful for steadying objects to be manipulated by the good hand.

Only one in seven patients recovers the use of their arm if it has been paralysed. If there is some movement at the hip and knee, it is likely that the patient can be taught how to walk again but stroke

sufferers who still cannot control their bladder at two weeks have a poor chance of walking.

Order of recovery

The order of recovery varies from one person to the other. The following table can be used, however, as an approximate guide for someone who has had a moderate to severe stroke.

- Can control his/her bowels;
- Can sit in a chair without slumping or sliding out of it;
- Starts to attempt to feed himself/herself with the good hand;
- Can control his/her bladder;
- Cooperates with good side on being moved;
- Stands better and starts to walk with two people assisting him/her;
- Attempts to wash, comb hair, shave, and part dress;
- Walks with one person's help, can usually get up alone;
- Walks independently, possibly with a tripod walker or stick;
- Can wash and feed independently;
- Attempts taking the stairs.

Sensation loss

Recovery is always slower in patients who have serious sensory problems, and this is particularly so if their understanding of where their arms or legs are in space is faulty. The ability of the brain to interpret messages from the affected side may be so poor that the patient shows no interest in the paralysed side, and even neglects it.

After six months

Physical recovery is largely over by six months and is greatest during the first three months. The following table illustrates the percentage of stroke sufferers who will not have recovered from a disability by six months. Any patient who cannot walk at six months is not likely to be able to walk again.

- Unable to speak 10%
- Still not able to control the bladder/bowel 10%
- Needs some help washing 10%
- Cannot walk alone 15%
- Needs some help eating 20%
- Needs some help with toileting 20%
- Needs some help to transfer from bed to chair 20%
- Needs some help with dressing and stairs 30%
- Needs some help to bathe 50%

Up to two years

Some further recovery can occur up to two years after the stroke. Thereafter, any improvement is usually the result of the patient having learnt some trick movements and not any actual improvement in the way their brain or nervous system is working.

In rare instance, however, definite improvement continues over a longer period.

Coping and support

A stroke is a life-changing event. It can severely dent a victim's emotional well-being as much as physical function. Feelings of helplessness, frustration, depression and apathy aren't unusual. Diminished sex drive and mood changes also are common.

Maintaining one's self-esteem, connections to others and

interest in the world are an essential part of recovery.

The following strategies may be extremely helpful for stroke sufferers and their caregivers:

Go easy; do not be too hard on yourself

Accept that physical and emotional recovery will involve tough work and take time. Aim for a 'new normal', and celebrate each bit of progress. Allow time for rest.

Get out of the house even if it's hard

Try not to be discouraged or self-conscious if you move slowly and need a cane, walker or wheelchair to get around. Getting out is good for you.

Join a support group

Meeting with others who are coping with a stroke lets you get out and share experiences, exchange information and forge new friendships.

Let friends and family know what you need

People may want to help but not be sure how. Let them know that you would like them to bring over a meal and stay to eat with you and talk, or to help you get out to lunch or attend social events.

Communication challenges

One of the most frustrating effects of stroke is that it can affect speech and language. Here are some tips to help both stroke survivors and caregivers cope with communication challenges:

Practice will help

Try to have a conversation at least once a day. It will help you learn what works best for you, help you feel connected and rebuild your confidence.

Relax and take your time

Talking may be easiest and most enjoyable in a relaxing situation when you have plenty of time. Some stroke survivors find that after dinner is a good time.

Say it your way

When you're recovering from a stroke, you may need to use fewer words, or to rely on gestures or your tone of voice to get an idea across.

Use props and communication aids

You may find it helpful to use cue cards showing frequently used words, pictures of close friends and family members, and daily activities such as a favourite television show.

Keep your chin up

Indeed, these are trying times, but if you keep hope, life can still be a joy. Just as the poet Emily Dickinson has said:

“Hope” is the thing with feathers—
That perches in the soul—
And sings the tunes without the words—
And never stops—at all—.

Vigyan Prasar Publications

A brief report based on the survey conducted by Manish Mohan Gore

Vigyan Prasar (VP) regularly participates in and organises book fairs/exhibitions for the outreach of its publications and ideas. Many visitors are attracted towards VP stalls wherever it is put up. It has been noticed that the general public, students and teachers like our books because they can learn science in an enjoyable manner. VP has produced almost 250 titles on various topics of science and technology in different languages, but majority of them are in English and Hindi. VP did a survey of the readers of its publications during 17th Delhi Book Fair (27 August-4 September 2011). The feedback questionnaire had ten multiple-choice questions and we got a spectrum of responses from the respondents. The questionnaire forms were distributed among the visitors of different communities and age groups. It was found that the majority of the respondents (88%) belong to young generation, which shows that today's youth is interested in popular science books.

In answer to a question about the reasons of liking the VP books, 82% of the respondents said that they liked our books because of innovative ideas/themes and approach. In response to the question related to the major aim of science communication, 77% of the respondents mentioned that the main aim of science communication is to encourage scientific research; 8.9% said that the aim is to create awareness about the environment; 2.1% said that the aim is empowerment of women; and only 12% of the respondents said that the aim of science communication is to enable people in rational decision making, which is the right option. Maybe, if science communication is added as a subject in school syllabi, then the children will be aware about its real purpose right from their childhood.

Our first Prime Minister Pt. Jawaharlal

Nehru had used the term scientific temper and its concept for the first time in his book *Discovery of India* (1946). He explained scientific temper as "an attitude of human being which enables him/her for the fearless search for truth".

In the survey a question was aimed at assessing the awareness about the term 'Scientific temper'. It was hoped that anyone who has been associated with science communication, should be aware of the



VP stall at Delhi Book Fair

meaning and purpose of the term scientific temper. But only 20% of the respondents knew the right answer; 80% were of the view that C.V. Raman had used this term first. This response shows that the common people are aware that C. V. Raman was India's famous scientist. Few also know that Raman had got the first science Nobel (1930) for India and the day of his famous discovery (28 February) is celebrated as *National Science Day* every year since 1987. In other words, we can say that majority of the people somehow correlate Raman with science and scientific temper. But it is not so in case of science communication. This confusion needs to be removed from public minds through effective science communication. It is imperative that programmes to promote scientific temper should be produced or commissioned by VP for children and the general public.

Another question was aimed at getting people's response on the need of a National Science Channel. In the response, 100% of the respondents say 'Yes', which means that all the people feel that a National Science Channel is necessary for the development of the scientific awareness in the society.

It was observed that the initiatives having innovative approach attract people more than that of the traditional ones. This is also applicable in the science communication.

In order to get input from the respondents, they were asked to give their suggestions about the new programmes which VP should take up. In response, 55% of the respondents suggested that VP should give more emphasis on children's understanding of science; 20% wanted that VP should communicate science through new media; and the remaining 19% wanted that teachers' training should be organised.

This data reflects the need for strengthening children's understanding of science. In this context science education with a

blend of science communicative approach at school level seems to be a viable approach for creating scientific awareness among children. In addition, the new and emerging technologies such as the Internet, Facebook, blogs, twitter, etc., can play a great role in communicating science. Science blogs are doing well in India.

On the basis of the analysis of the data, findings of the feedback study, and the suggestions of the respondents, it can be concluded that Vigyan Prasar is playing a vital role in science communication in the society. Though the publications and other science popularisation activities undertaken by VP are liked by majority of people, the suggestions and findings reveal that the existing activities being taken up by VP are not sufficient. They need to be expanded and strengthened so that the basic objectives of VP could be achieved. ■

Recent developments in science and technology

A novel device to reduce milk lactose

Lactose intolerance is the most common food intolerance that affects at least one out of ten people. These people lack an enzyme called β -galactosidase that is essential for breaking down the lactose molecule and make it



β -galactosidase molecule

digestible. Now a team of researchers from School of Biotechnology, Banaras Hindu University, led by Arvind M. Kayastha has designed a novel device by attaching the β -galactosidase enzyme to a graphene nanosheet that could be used to reduce lactose, making it useful in the food industry for manufacturing low-lactose products (*PLoS One*. 2012;7(7):e40708. Epub 2012 Jul 18).

Lactose is a large sugar molecule made up of two smaller sugars, glucose and galactose. It is this sugar that creates problem for some individuals who are unable to digest milk or milk products. The small intestine is where most chemical digestion takes place. Because the lactose molecule is large, it cannot pass through the wall of the small intestine into the bloodstream. So, in order for lactose to be absorbed from the intestine and into the bloodstream, it must be first broken down into glucose and galactose. The glucose and galactose are then absorbed

by the cells lining of the small intestine.

Lactose is usually broken down in the body into glucose and galactose by an enzyme called lactase, which is a β -galactosidase. Normally the digestive systems of infants and children produce plenty of lactase, but with growing age the amount of lactase produced by the body decreases and often it becomes sufficient only to handle a glass or two of milk at a time. When the production of lactase drops below a certain minimum amount, the body is not able to break down lactose and intolerance to lactose appears. However, deficiency of lactase enzyme is seen in some individuals even in childhood or at a young age.

The deficiency or lack of lactase can cause severe digestive problems – a condition known as ‘lactose intolerance’. When enough lactase is not present in the digestive fluid, the lactose present in milk and milk products is not broken down effectively in the small intestine and it passes along the intestinal path to a region where it undergoes fermentation in presence of bacteria, producing gases such as carbon dioxide and hydrogen, and lactic acid, which is a bowel irritant. The combination often causes discomfort, abdominal cramps, gastric distress and diarrhoea.

Unfortunately, there is no way of increasing the amount of lactase enzyme in the body of those with lactose intolerance, but symptoms can be controlled through lactose-free diet or use of lactase additives in food. People with lactose intolerance can safely take buttermilk, cheese, and fermented milk products such as yogurt because these products have less lactose than milk and have less impact on body chemistry.

In the recent study the researchers first produced a graphene nanosheet using graphite oxide and modified it with chemical reagents. Next they extracted β -galactosidase enzyme from chickpea seeds and attached the enzyme to the nanosheet using organic compounds such as cysteamine and glutaraldehyde. Then they studied the efficacy of the enzyme-attached nanosheet for reducing lactose in milk and whey. The device successfully reduced lactose in both samples.



Biman Basu

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Banana genome sequenced

An international consortium of plant scientists has completed the first sequencing of the banana genome, which has been found to contain more than 36,000 genes, slightly more than in the human genome. The genome that has been sequenced ran to 523 million ‘bases,’ the chemical units that make up DNA and encode the genetic information (*Nature*, 12 July | doi:10.1038/nature11241). Bananas (*Musa* spp.) are vital for food security in many tropical and subtropical countries and the most popular fruit in industrialised countries. The *Musa* domestication process started some 7,000 years ago in Southeast Asia. It involved hybridisations between diverse species and subspecies, fostered by human migrations, and selection of seedless hybrids, which were later widely dispersed by vegetative propagation.

Banana is an important crop in developing countries that provides food and economic security for more than 400 million people in some of the poorest parts



The common dessert banana (left) is shown with the seed-filled wild variety (right) that was used for genome sequencing. (Credit: Angeliq D'Hont, CIRAD)

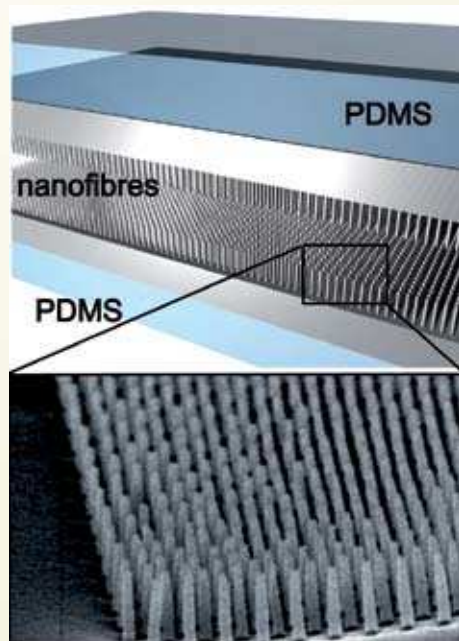
of the globe, but they are under constant threat from a range of parasites. Bananas are difficult to breed and are under attack from a host of diseases and other pests. The DNA data from a key species would now provide an important clue to protecting the fruit. The completion of the genome sequence is important for India, which is the world's largest producer of bananas.

The banana is the first non-grassy plant in its botanical class, the monocotyledons, or monocots, whose entire genome has been sequenced. Monocots include grasses, palms, lilies and orchids. Dicotyledons, or dicots, on the other hand, comprise more evolutionary recent plants including the majority of flowering plants and all true trees. Knowledge of the banana genome is important because bananas that are cultivated, unlike their wild relatives, are seedless and develop without going through a process of pollination, fertilisation and seed production. These domesticated forms are mostly multiplied by vegetative propagation, by using a part of the parent plant. As a result, the offspring are genetically similar to the parent and such similarity makes most of the present day cultivated varieties susceptible to fungal, bacterial and viral diseases. From the knowledge of the entire genome of the plant it may be possible to identify the genes responsible for disease resistance as well as ones for other important traits such as fruit quality.

For sequencing the international team used the genome of a banana variety called DH-Pahang, found in south-east Asia, which is not good to eat but is able to resist the devastating 'Panama disease' fungus that attack the roots of the banana plant and has been spreading in Asia. If the genes that provide such resistance could be characterised, they could be transferred to other cultivated varieties to protect them. No wonder the sequencing of the banana genome has been described as a crucial stepping-stone for genetic improvement of banana. According to the researchers, the Musa genome sequence reported in the paper bridges a large gap in genome evolution studies. As such, it sheds new light on the monocotyledon lineage. The Musa genome sequence is therefore an important advance towards securing food supplies from new generations of Musa crops, and provides an invaluable stepping-stone for plant gene and genome evolution studies.

An electronic sensor like human skin

The human skin is exceptionally sensitive to touch; it can feel even the presence of a hair touching it. Till recently, no electronic sensor could perform as well as the human skin in detecting pressure and movement. A team of South Korean researchers from Seoul National University, led by C. Pang has now produced a simple, highly sensitive and flexible sensor based on the intermolecular forces between "nanohairs", which can be used as artificial skin in robots. The device was fabricated as a synthetic equivalent to



When sandwiched together, two layers of tiny platinum-coated hairs can sense pressure, shear and torsion like human skin.

human skin. It is so sensitive that it can distinguish and measure pressure, as well as shear stress and torsional forces, and can be easily and economically manufactured (*Nature Materials*, doi:10.1038/nmat3380, 2012).

The device is based on two interlocked arrays platinum-coated polymeric nanofibres that are supported on thin layers of a flexible polymer called polydimethylsiloxane (PDMS). The electronic sensor is so sensitive that its interlocking hairs can detect the gentle steps of a small insect such as a ladybird beetle walking on it. The flexible electronic sensor made from nanohairs can also be strapped to the wrist and used as a heart-rate monitor.

Scientists have been trying to reproduce the qualities of skin in a suitable synthetic sensor for a long time, but without success. It has proved to be a tough challenge because there are severe design constraints on such sensors that make them highly complex to fabricate. Most importantly, the device needs to be thin and flexible enough to wrap around areas of high curvature such as fingers and toes without being damaged. This is problematic because most of the materials used in electronics, such as silicon and germanium, are hard and brittle.

The Korean researchers got over the problem by using two layers of a flexible polymer, each with a dense carpet of interlocking platinum-covered nanohairs. As the hairs are covered with platinum, they provide an electrical connection between the otherwise separate layers of polymer. The sensor is based on piezoresistance – where changes in the electrical conductivity of a semiconductor are caused by applied mechanical stress. Any pressure on the sensor at a particular point brings the two layers closer together, thus increasing the amount of contact between the hairs and reducing the electrical resistance. When the pressure is removed, the two layers return to their equilibrium separation and the resistance returns to normal.

The design is sensitive to pressures of just five pascals – gentler than the lightest of touches. By analysing how the resistance changes in response to mechanical stress and then recovers when the stress is removed, the new sensor can distinguish between three types of mechanical strain: pressure, which comes straight down on the sensor; shear, a frictional slide along the surface; and torsion, a twisting motion. Human skin can distinguish between these types of strain, but most artificial sensors cannot.

The researchers have shown their device's sensitivity in several demonstrations. They measured a small water droplet bouncing on a hydrophobic surface and also measured the change in the speed and intensity of a volunteer's heartbeat after vigorous exercise using a sensor attached to the artery at their wrist.

According to the researchers, flexible sensors that respond to stimuli much like real skin have a variety of potential applications, including biomedical sensors, artificial skin, and flexible displays like highly sensitive touch screens. The fact that

the new sensor produces different signals in response different types of force is important because it is quite similar to real sensing mechanism of our skin, so that the sensor is potentially useful for future skin electronics. The technology also brings researchers one step closer to designing a sensor that could be integrated into artificial limbs that could provide feedback on real-world sensory information just like real limbs.

Pluto's fifth moon discovered

Pluto, once considered the outermost planet of the solar system that was relegated to a "dwarf planet" status in 2006, has again sprung a surprise. Only a year after Hubble Space Telescope scientists discovered Pluto's still unnamed fourth moon, they have found a fifth. Pluto's new moon, dubbed P5 until it gets a proper name, is quite small – estimated to be irregular in shape and only 10 to 25 kilometres across. Even in the Hubble's best images, the new moon – some 5.9 billion kilometres from the Sun – is visible only as a speck of light. The orbit of the new moon is still uncertain, though the tiny moon appears to be circling in the same

plane as Pluto's other satellites, roughly 42,000 km from the dwarf planet. That puts P5 nearer to Pluto than Nix, Hydra, and the not-yet-named P4. Pluto's largest moon – the 1,050-km-wide Charon, was discovered in 1978. Its two smaller moons, Nix and Hydra, were found in 2005. P5 is incredibly faint – half as bright as P4, and roughly one one-hundred-thousandth as bright as Pluto – and orbits relatively close to the dwarf planet.

The new moon was discovered on 7 July 2012 by chance, in the course of checking out the potential collision hazards to NASA's *New Horizons* spacecraft, which is due for a flyby of Pluto, passing 10,000 km from the dwarf planet on 14 July 2015. According to NASA, the discovery will help the *New Horizons* spacecraft navigate its way to the planet safely. Moving past the dwarf planet at a speed of more than 48,000 km per hour, *New Horizons* could be destroyed in a collision with even a tiny piece of orbital debris.

All of the moons of Pluto discovered so far appear linked to the motion of the much



This image, taken by NASA's Hubble Space Telescope, shows five moons orbiting the distant, icy dwarf planet Pluto. The green circle marks the newly discovered moon, designated P5. The brightness of Pluto and Charon has been reduced by mask to make the smaller moons visible in the image. (Credit: NASA; ESA; M. Showalter, SETI Institute)

more massive Charon: their orbits follow certain resonances with the orbit of the larger satellite. Nix is in what is called a one-to-four resonance with Charon – it orbits Pluto once for every four orbits of Charon – whereas P4 is in a one-to-five resonance, and Hydra is in a one-to-six resonance. The newly discovered P5 also appears to have fallen into resonance with Charon as well, completing one orbit of Pluto for every three orbits of Charon.

Letters to the editor

Venus Transit

Dream 2047 is really a pleasure to read. The editorial on Venus Transit by Dr. Subodh Mahanti (June) was excellent. Such articles are very helpful in creating interest about celestial things among students of astronomy.

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Irrational numbers

The article 'Niceties of Numbers' by Rintu Nath (July 2012) gave a wealth of information about various numbers. He has mentioned two categories of irrational numbers, viz., algebraic and transcendental numbers. Going into the history of mathematics, it was Johann Lambert who was first to prove in 1760 that π is an irrational number.

Mathematicians discovered that irrational numbers, such as $\sqrt{2}$, $\sqrt{3}$, etc., could be obtained as roots of polynomial equations with rational coefficients. Hence, such numbers were called algebraic irrational numbers. However, French mathematician Adrien-Marie Legendre conjectured that π could not be an algebraic irrational number. In 1882, German mathematician Ferdinand von Lindemann proved that π indeed could not be obtained as solution of any polynomial equation. Such numbers which go beyond or 'transcend' algebra gradually came to be known as transcendental numbers.

The number e , the base of natural logarithm, was also shown to be irrational by Swiss mathematician Leonhard Euler. That is why it is also known as Euler's number. However, only in 1883, French mathematician Charles Hermite proved it to be transcendental.

Thus, π and e were proved to be transcendental by the 19th century. However, as mentions by the author, the status of π^e , π^π , e^e , and e^π yet remains to be settled.

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Articles
invited

Dream 2047

Vigyan Prasar is inviting original popular science articles for publication in its monthly science magazine *Dream 2047*. At present the magazine has 50,000 subscribers. The article may be limited to 3,000 words and can be written in English or Hindi. For details please log-on to www.vigyanprasar.gov.in

Workshop on Current Trends in Chemistry Teaching- Communicating the Excitement of Chemistry

Vigyan Prasar (VP), in collaboration with Jagadis Bose National Science Talent Search (JBNSTS), organised a three-day workshop at Kolkata during 5–7 June 2012. The workshop was part of VP's national campaign for IYC (International Year of Chemistry) 2011 to celebrate achievements of chemistry and its contribution to the well-being of human kind. Forty-three teachers and science communicators from eight districts of West Bengal attended the workshop.

The workshop was inaugurated by Dr. Dhrubojyoti Chattopadhyay, Pro-Vice Chancellor, Calcutta University. In his inaugural address Dr. Chattopadhyay expressed his happiness for conducting such workshop for school teachers and gave a presentation on understanding the chemistry of life. Dr. Sanjib Bagchi, Professor Emeritus, Department of Chemistry, Presidency



Dr Samar Bagchi delivering a talk on science through history

University, Kolkata, delivered the keynote address on 'Molecules, photons and their interactions'. Dr Papiya Nandi, Director, JBNSTS, welcomed all the participants and briefly described the programmes of JBNSTS. Shri Rintu Nath, Scientist, VP, stated the objectives of the workshop and explained how the workshop may help teachers in doing hand-on activities in classroom teaching for better appreciation and understanding of

science by students. Shri Nath also briefly described various programmes of Vigyan Prasar. In post-lunch session of day 1, Dr. Nitin Chattopadhyay of Jadavpur University, addressed the participants and explained why teaching is a privilege. Dr. Abhijit Kar, Scientific Officer, JBNSTS, distributed the Chemistry Kits developed by Vigyan Prasar to all the participants. He demonstrated how to use the kit. Many participating teachers demonstrated different innovative activities related to classroom teaching involving the hands-on activities. Later, a film "Greatest discoveries in chemistry" was shown to the participants. Day 1 was finally concluded by a special lecture on transit of Venus by Mr. Basudeb Bhattacharya, President, Sky Watchers' Association, Kolkata.

On day 2, observation of transit of Venus was organised for the participants. A module "Teaching chemistry- an activity based approach", specially designed for the workshop, was started after this event. In this activity-based module, Dr. Arindam Rana of City College, Kolkata and Dr. Abhijit Kar demonstrated a number of innovative activities. Qualitative analysis, fundamentals of pH-metric titration, quantitative analysis, and acid-

base chemistry were carried out by the participants. Experiments with natural products and their comparable synthetic substitutes were performed. A number of activities based on chemistry in daily life were demonstrated and explained by Dr. Rana. All the sessions were interactive and participants took part in interacting with the resource persons and did hands-on activities themselves.

On day 3, Dr. Samar Bagchi, eminent science communicator, delivered a talk on science through history. He outlined the progress of science through different civilisations. In the next session, Dr. Dilip K. Maity, Chief Co-ordinator, Chemistry, BARC, talked about philosophy of setting of question papers and evaluation process in bringing out innovation and creativity in students. In the last session, Professor Panchanan Pramanick of IIT, Kharagpur delivered the valedictory lecture on the applications of nanoscience and technology in our daily life and its associated technological developments.

A few participants shared their views on the workshop and explained how it would help them in utilizing the resource materials provided by VP in doing hand-on experiments.

(Report : Rintu Nath)



Participants doing hand-on activities during the workshop

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VP website

Join Vigyan Prasar digital library to read online publications. You may also join the discussion forum to ask science and technology related questions and also answer fellow participants' queries. We also have streaming science videos, science radio serials, online science quiz, hand-on activities, and many more features and programmes related to science and technology. Log-on to www.vigyanprasar.gov.in

Science Awareness Programme in Madarasa

Vigyan Prasar in collaboration with Vigyan Chetna Samiti, UP organised a Science Awareness Programme at Madarsa Islamia Jamai-Ul-Uloom, Village Masoori, District Ghaziabad, UP on 13th March 2012.

Interactive sessions on innovative experiments of Physics & Chemistry, science



Shri Nimish Kapoor interacted with students

behind miracles and scientific temper were organized. Resource persons Dr. Ashok Maitrya, Mr. Mahesh Verma and Mr. Adnan Ahmad showed many scientific experiments and explained them to the students. These experiments were demonstrated to orient students and teachers in innovative methods of science and to reveal the superstitions among our society. Resource Persons made an active interaction with the students of Madarsa. Shri Nimish Kapoor, Scientist, Vigyan Prasar conducted an interactive session on scientific temper among students. Shri Indu Mittal, Gen.Secretary, Vigyan Chetna Samiti also interacted with students. Popular science literature from Vigyan Prasar was distributed among the students and teachers. Madarsa authorities Mr. Wahid (Manager) and Mr. Noormohammad (Principal) thanked the participants and resource persons presented vote of thanks to all attended the programme.

(Report : Nimish Kapoor)



Vidyarthi Vigyan Manthan: A national programme to identify and nurture scientific temper among children



Vigyan Prasar and Vijnana Bharati jointly announce a massive science propagation programme called Vidyarthi Vigyan Manthan (VVM) among school children. VVM is a national programme focussed on popularising science among school students from 6th to 12th standard. The primary objective of VVM is to identify potential young minds with scientific temper and nurture them.

Vigyan Prasar is an autonomous organisation under Department of Science and Technology, Government of India. Vijnana Bharati is a national movement in the field of science and technology, working throughout the country having the largest network of organisations and individuals.

As part of VVM, the organizers will (1) hold competitive tests across the country to identify bright and creative students; (2) take them through different levels of workshops to give hands-on training for the qualifiers of the tests; (3) arrange visits to various research and development (R &D) institutions to give them wider exposure to different fields of science; and (4) identify successful students from across the nation and motivate them with prizes and certificates. The winning students will also be mentored appropriately, which will help them to carry forward their education in higher levels of science.

The broad areas of VVM syllabus for the competitive tests are as listed below.

1. India's contribution to science and technology (from traditional to modern)
2. Noble laureates of India
3. Inspiring lives of scientists and their contribution
4. The Iron pillar of Delhi
5. Ayurveda and medicinal plants of India
6. Conventional, non-conventional and clean energy sources of India
7. Development and contributions in health and medicine in India
8. Agriculture, biotechnology and nanotechnology in India
9. Space and astronomy in India
10. Science and its various branches

The study material comprising India's contribution to science and technology (from traditional to modern) and the details of VVM shall be available for download on the website of Vigyan Prasar www.vigyanprasar.gov.in and Vidyarthi Vigyan Manthan www.vvm.org.in.

We request school authorities to register the maximum number of students from each school before 30th September, 2012. The first and second level of examination has been decided on 2 December, 2012. For any queries or further communication, contact at National Coordinator, 501, King Apartment, Behind reliancefresh, Navalakha Square, Indore (MP) - 452001, Mob: 9589832360 Email: vmbharat@gmail.com website : www.vvm.org.in



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