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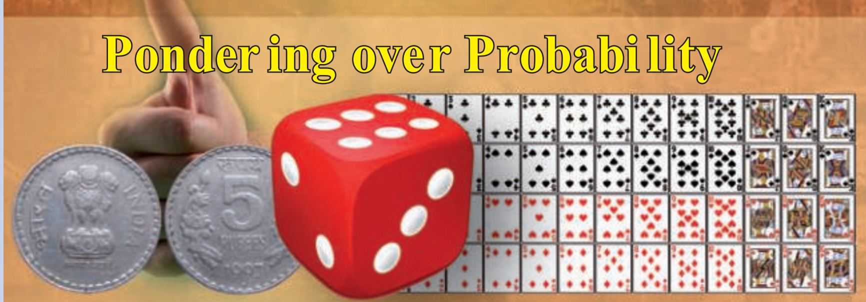
National Mathematics Year 2012

Special issue to mark the 125th birth anniversary

Srinivasa Ramanujan



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

A national mission for effective value-added S&T communication

Dr. R. Gopichandran

The Planning Commission has to be commended for its inclusive and extensive efforts to define the National Mission on Sustainable Agriculture (NMSA). The imperatives of sustainable development that the twin goals of mitigation and adaptation in response to challenges posed by climate change, could be expected to be duly addressed in defining actions as part of the mission.

One of the most important facets of implementation of these plans is effective communication with farmers at the grass-root level across the nation. The India Meteorological Department is working on micro-level climate information gathering systems to help farmers adopt location-specific farming practices. The State Agricultural Universities are also joining this collective effort to improve preparedness of farmers.

Expeditious delivery of information would be the key to improved preparedness of stakeholders to act. This is an important prerequisite, in close association with the outreach initiatives of national missions and related institutions, for enabling science and technology communication to serve two important purposes, namely, (i) Deliver appropriate information in a timely manner, ideally as a forerunner to the extension and other information delivery services, and (ii) Improve preparedness of farmers to receive information that will be delivered through the core mission activities. This will help farmers appreciate the relevance of information that will be presented to them and expedite appropriate responses.

Importantly, the forerunner can generate valuable insights on the innovations and adaptive abilities of farmers central to enable transitions to climate-efficient collective action. These could pertain to locally feasible mitigation and adaptation interventions. These insights can be integrated into the information modules that are proposed through the mission. Additionally, the mission can also look for local knowledge resources that can be coalesced for wider national benefit through appropriate knowledge sharing mechanisms.

For any such mission to succeed, support at the public policy interface is vital. Most importantly, from a public policy point of view, the forerunner can generate valuable information on the status of enabling circumstances at the ground level, which may pertain to such aspect as: whether alternatives are readily available and accessible to the farmers, and what the collective impact of interventions/alternatives could be on the livelihood options of farmers.

Answers to these questions can be embedded in the logical framework of science and technology communication services. These considerations will embellish modules with information on locally relevant tools and techniques on which the capabilities of farmers can be built in a focussed manner. It is therefore equally important to define appropriate institutional mechanisms that enable the use of alternatives. Such synergies among tools of public policy facilitation would ensure well-informed action as a sequel to information delivery.

Scientists take note of the importance of the chemical ecological characteristics of crop productivity with implications for crop mix and the occurrence and distribution of related vegetation in farming systems. Tritrophic interactions are also modulated by the chemical environment, calling for a holistic understanding of allelochemical and allelopathic interactions and hence sustained production cycles. Individual and synergistic interactions/influences have also to be accounted for in developing and implementing preventive strategies.

An overarching consideration of the science and technology communication forerunner also is to help farmers secure a wider perspective on the causes and effects of climate change (the case in point), and rightly so, and reinforce their scientific temper. The NMSA is a valuable entry point for collective action on these aspects.

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Pondering over Probability

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Last Sunday, I was very busy. Two of my friends had birthday celebrations on the same day. They are my best friends. I could not miss one for the other. So I attended both birthday parties. It was indeed a very enjoyable day celebrating their birthdays with other friends.

When I returned home, my uncle asked, 'My dear Googol, how were your parties?'

'Uncle, both parties were wonderful – I enjoyed them so much,' I could not resist my ecstatic expressions.

'That's very nice,' uncle smiled looking at my buoyant face.

'Uncle, it must be a very rare occasion that two of our classmates have the same birthday when we are only 50 friends in the class,' I was still reflecting on my moments of happy hours.

'On the contrary, it is very likely that two of your friends will have the same birth date. To be precise, there is a 97% chance that it would be so.' Uncle quipped.

'How can that be possible? Ignoring the leap years, there are 365 days in a year. How could it possibly be that two persons in a group of 50 will share the same birth date with such certainty?' I was completely perplexed.

'To understand that you have to get the concept of *probability*,' uncle replied.

'Please uncle, tell me more about it.' I pleaded with my uncle.

'Right, first tell me how you would mathematically arrange the following words in an ascending order: *coin*, *dice* and *card*.'

'I can tell you how they should appear in a dictionary. It should be *card* first, then *coin* and finally *dice*.' I tried to reason.

'Well, let me take it one by one. How many sides a coin has?' Uncle asked me again.

'Simple, a coin has two sides – *Head* and *Tail*.'

'Correct. Let's say, we plan an *experiment* which is tossing an unbiased coin once. In statistical jargon, we can say that the *outcome* Head (H) or Tail (T) is an *event*, and the collection of all such possible events is called the *sample space*.'

'That means, if I *toss a coin once*, all possible events are only Head and Tail and therefore total number of possible events equals to *two*. Using the short name, I can say that the sample space will include H and T.'

'Exactly. The sample space is also denoted by the English or Greek letters like *S*, Ω or *U* (for universe), and the events within a sample space are sometime written with a curly bracket. So, for this particular experiment, we can write: $S = \{H, T\}$.' Uncle explained.

'I got it now.' I replied affirmatively.

'If you understand this, then we can very easily *estimate* the probability of an event.'

Sample space of tossing a coin once

'What is a *probability*?' I interrupted.

'The term 'probability' has a very well-defined meaning in statistics. It is a measure of the expectation that an event will occur or a statement is true.'

'It seems a bit complicated,' I confessed.

'Don't worry. Let's take the example of tossing a coin.' Uncle took out a coin from his pocket and continued explaining me the coin tossing experiment. 'Imagine, we are doing an experiment of tossing a coin once. You know the sample space of all possible events from a single toss of a coin. Now, we can find out what is the probability of getting a 'Head' after a single toss. This can simply be obtained by: the number of times that the desired event i.e. 'H' is appearing in the sample space divided by the total number of events in the sample space.'

'Let me see if I understood it properly. The desired event is 'H'. The total number of events in a sample space for this experiment is *two* i.e. {H, T}. And, the desired event (H) is occurring in the sample space only *once*.'

'Very good. Backed with this information, we can now estimate the probability of getting a 'Head' in the experiment of tossing a coin once as: $Pr(H) = 1/2$.'

'It's very interesting. I got it now. So, the probability of a Tail in this experiment, or $Pr(T)$ also equals to 1/2.'

'You're right. Now, if you look at this concept carefully, you will notice another interesting property of probability that can be derived from this definition. By definition, the value of probability ranges between 0 and 1 inclusive. When it is zero, the desire event is *not* present in the sample space, and it is also called a *null event* or *impossible event*. If it is 1, all events in a sample space are of the desired event and this is absolute certainty. The higher the probability i.e. as it moves towards 1, the more certain we are that the event will occur.'

'So, Pr(H) or Pr(T) is just half-way of this range.'

'Yes, that's true. Well, in this context, let me tell you few more things. To estimate the probability in this way, it is assumed that each event in the sample space is *equally likely*. Statistically, it means that each event can occur with equal probability. Also, here we defined the sample space in a very simplified manner, but the mathematical definition of probability can extend to *infinite sample spaces*, and even an *uncountable sample space*.

Anyway, we will not go into further details on this.'

'Uncle, please give me another example of probability.'

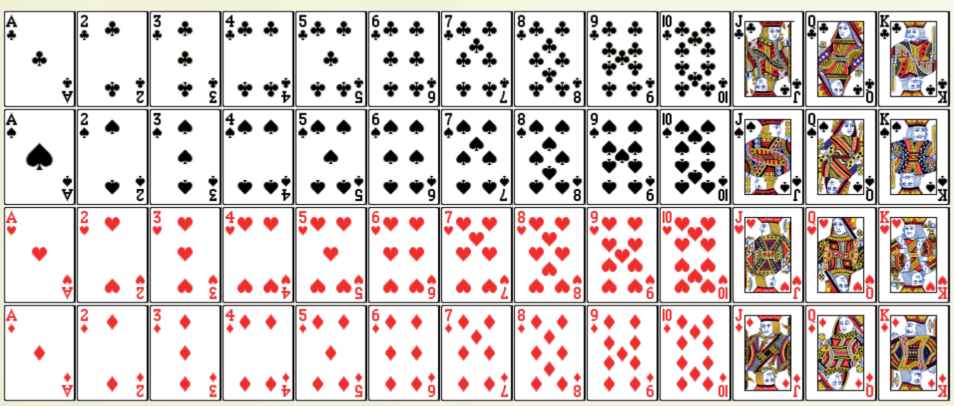
'Why don't you give a try on the *dice* example? If I roll a dice once, what is the probability of getting a 6?'

Sample space of rolling a dice once

'Oh yes, let me try it. There are *six* sides in a dice, and hence all possible events in one throw of a dice will include the sample space as {1, 2, 3, 4, 5, 6}. The desire event '6' happens only once, and so the Pr(6) = 1/6.'

'Well done. Let's talk about the *card*? Well, by card, I mean the playing cards. You may know that a deck of playing card has 13 cards of each suit (Ace or 1, 2 to 10, Jack, King and Queen). There are four suits: Clubs, Spades, Hearts and Diamonds. So, the total number of playing cards in a deck is 13 x 4 = 52.'

'So, the sample space includes a total of 52 events.'



Sample space of a deck of playing cards

'For some kinds of experiments, there may be two or more plausible sample spaces available. For example, when drawing a card from a standard deck of 52 playing cards, each one card can be an event and hence all possible events in the sample space is 52. However, one possibility for the sample space could be the rank (Ace through King ignoring the suit) and hence total events in the sample space are 13, where each event is appearing four times. Another possibility could be the suit (clubs, diamonds, hearts, or spades) where all possible events in the sample space are four, and each event is appearing 13 times. Now, if we are interested in each card as an event, could you please tell me what the probability of an Ace of Clubs is?'

'There is only one Ace of Clubs in all possible events in the sample space. So, Pr(Ace of Clubs) = 1/52.'

'That's nice Googol. Could you find out what the probability of an Ace of any suit is?'

'Let me try. There are a total of four Aces (of Clubs, Spades, Hearts and Diamonds) in the sample space. Then, Pr(Ace of any suit) = 4 / 52 or 1/13.'

'You've got this one too. Note here that you can solve this problem considering the sample space for the rank of cards (Ace through King) as mentioned before.'

'Yes uncle, I could get this now.'

'Let's make the game of probability slightly more complicated. We will go back to the dice experiment again. You now have a clear idea about sample space from a single throw of a dice. Can you figure out the probability of getting a 1 or 6?'

'Well, the sample space of a single throw of dice is: {1, 2, 3, 4, 5, 6}. Clearly, the Pr(1) = 1/6 and Pr(6) = 1/6. The desired events (1 or 6) are happening twice in the sample space. I guess, Pr(1 or 6) = 2/6. Am I right uncle?'

'Yes, you are thinking in the right direction. The desired event here indeed is either 1 or 6 which is occurring twice in the sample space. Another way to solve this problem is to add the Pr(1) and Pr(6).'

'Yes, that's true. Pr(1 or 6) = Pr(1) + Pr(6) = 1/6 + 1/6 = 2/6.'

'Remember, you should not attempt *adding two or more probabilities* wherever you see them. If you do such operation indiscriminately, you may soon get a probability greater than 1 which is not possible (since the range of probability is zero to one). So, there is a rule for it. This is called the addition law of probability. You can simply add two probabilities if they are *mutually exclusive*. This is a statistical expression which means two or more events cannot occur at the same time, or the occurrence of an event excludes the occurrence of another event.'

'Please, give me an example.'

'For example, if you roll a dice once, events 1 and 6 can be termed as mutually exclusive events as both of them cannot appear in a single roll.'

'Yes, I understand this now. I think that we can get other examples of mutually exclusive events from the roll of a dice. For example, getting 1 or 2 or any other numbers are also mutually exclusive.'

'That's correct, Googol. All events in a single roll of dice are mutually exclusive. To extend this concept further, the sum of probabilities of all mutually exclusive events in an experiment must add to 1. For example, rolling a dice once, the sum of *probabilities of* all mutually exclusive events in the entire sample space must add to one. In other words, P(1) + P(2) + P(3) + P(4) + P(5) + P(6) = 1.

'I got it. For the single toss of a coin experiment, H & T are all possible mutually exclusive events in the entire sample space. Hence, P(H) + P(T) must be equal to 1.'

'Yes Googol, you got it right.'

'If I understood you correctly, you said that we cannot simply add probabilities when the events are *not* mutually exclusive.'

'Yes, that's true. If two events A and B are not mutually exclusive, then a simple addition will not do. This is because it will add the probability of occurrence of both A and B twice. The occurrence of two events together may also be termed as *intersection* or *joint events*. In that case, the rule is to subtract the probability of intersection once. In other words, P(A *or* B) = P(A) + P(B) – P(A *and* B).'

'How do I get the P(A *and* B)?'

'We will talk about this soon. For the time being, note here that the word 'or' is indicative of using the law of addition. Well, applying the addition law of probability, could you please tell me the probability of getting an even number from rolling a dice?'

'There are three even numbers 2, 4 and

6 out of six numbers in the sample space. Therefore, the probability of getting an even number should be: Pr(2 or 4 or 6) = 3/6. Since these events are mutually exclusive, we can obtain this estimate by adding each probability: Pr(2 or 4 or 6) = 1/6 + 1/6 + 1/6 = 3/6.'

'That's right. Let's go back to our coin experiment again. Let's assume that the experiment now includes tossing a coin twice.'

'Is there a difference between tossing a coin twice and tossing two coins simultaneously?'

'It will not make any difference because the events are independent,. I'll explain this soon. Before that, could you now guess the sample space from such experiment i.e. tossing a coin twice or tossing two coins?'

'Well, the sample space for the first toss is: {H, T}, and so it is for the second toss. How can I get the sample space for the full experiment?'

'It's easy if you think about one event at a time. In the first toss, let's focus on the first event of the sample space, which is the 'H'. We know that the sample space in the second toss is: {H, T}. If we write the first and second toss together, the sample space can be expressed as: {HH, HT}. Similarly, with T, you will get: {TH, TT}. Putting those together, all possible events (or the sample space) for the experiment is: {HH, HT, TH, TT}.

'Yes, that's very interesting. I understand it now.'

'Well, then tell me the probability of getting one H from the first *and* one H from the second'

'I can clearly see how to estimate this. The desired event is HH and hence Pr(HH) = 1/4.'

'And, the probability of getting a 'H' in the first toss and a 'T' in the second toss...'

'The desired event is HT and so Pr(HT) = 1/4 again.'

'And, the probability of getting a 'H' and 'T' at any order, i.e. irrespective of any toss...'

'That means, both HT and TH are our desired events. Clearly, Pr(HT or TH) = 2/4, or we can add two probabilities since they are mutually exclusive, and we will get the same answer: 1/4 + 1/4.'

'You're doing well, Googol. Now, there is another interesting concept hidden in this experiment. Actually, tossing a coin twice can be termed as two *independent* events. Statistically, two or more events are independent events if the occurrence of one does not affect the probability of occurrence of the other.'

'Please explain this with an example.'

For example, if I toss a coin and if it comes as a 'Head', this outcome will not affect how the coin will behave if I toss the coin again. That means the P(H) in the first toss is 1/2, and the P(H) of the second toss will still be 1/2.'

Sample space of tossing two coins once (HH, HT, TH, TT)

'That means, rolling a dice twice or rolling two dice simultaneously will also result independent events since the occurrence of an event in the first roll will not affect the probability of events in the second roll.'

'That's correct. Now, here is another interesting law of probability. If two or more events are independent, then you can simply *multiply the probabilities* of each event to estimate the *joint probability* of all events. This is also called the *multiplication law of probability*. For example, for each toss of a coin, Pr(H) = Pr(T) = 1/2. If I toss a coin twice, the probability of getting one H from the first *and* one H from the second toss is: Pr(HH) = P(H from the first toss) x Pr(H from the second toss) = 1/2 x 1/2 = 1/4. We can do this multiplication, because occurrences of Head in the first and the second toss are independent.'

'And this is another way to get the results that we have seen before.'

'Yes, you are right. Here, the word 'and' generally indicates a possible use of the multiplication law of probability. Of course, as the experiment gets more complicated, you have to be very careful about identifying the events that are independent. For example, the probability of getting a 'H' and 'T' of any order from several tosses of a coin will include probabilities involving both independent and mutually exclusive events.'

'If the events are *not* independent, we can't then simply multiply two probabilities to get the joint probability.'

'Yes, that's true. Then the concept of *conditional probability* will come into play since the occurrence of one event is conditional or dependent upon another event. But I am not going into the intricacies of the conditional probability at this moment.'

'Okay, I will remember this note while applying the multiplication law of probability. Anyway, estimating probability with rolling two dice may be a little difficult problem. Uncle, could you please help me?'

'First, tell me if the word 'dice' is a singular or plural noun?' uncle asked me.

'I think that dice is a plural noun. But what's its singular form?'

'Historically, *dice* is the plural of *die*, but in modern Standard English, the word *dice* is used as both the singular and the plural. Anyway, here is the simplest problem. What's the probability of getting two sixes in rolling two dice?'

'Rolling two dice and getting a 6 in each of them are independent events. So, Pr(6 and 6) = 1/6 x 1/6 = 1/36.'

'Now, tell me if you roll two dice, what is the probability of getting the sum of two values as 7?'

'That's a bit complicated for me,' I confessed.

'There are a total of 36 combinations that two dices can produce. You can easily get it if you follow the same logic as we used for two coins problem. In other word, the sample space will include all these 36 combinations. Out of these 36 events, there are six events that will produce a 7. These are (6,1), (5,2), (4,3), (3,4), (2,5) and (1,6). Therefore probability of having a 7 is 6 out of 36, i.e. 1/6.'

'I got it now. Similarly, the probability of getting the sum as 11 is 2/36, as two combinations (6, 5) and (5, 6) will produce the sum as 11. The probability of getting the sum as 10 is 3/36, and so on."

'Here, is another tricky question. You just told me the probability of getting two sixes in a roll of two dice. Now, what is the probability of *not* getting two sixes in a roll of two dice?'

'Pr(6 and 6) = 1/36. But the question is of *non-occurrence* of these two events.' I was trying to figure it out.

'This is easy. Remember, the total probability of all mutually exclusive events in an experiment will be 1. With the help of this property, we can easily find out that the Pr(Not 6 and 6) = 1 – 1/36 = 35/36.'

'Yes, I understand it now – it simplifies the thing so much. For a single throw of dice, we can similarly say that: Pr(Not getting a 6) = 1 – Pr(6) = 1 – 1/6 = 5/6. Am I right?'

'You are absolutely right. In statistics parlance, this is also termed as *complementary event*. In probability theory, the complement of any event A means that the event A does not occur. It is expressed as A', A^c or $\bar{A}$. As we said earlier, P(A') = 1 – P(A). The events A and its complement are also mutually exclusive. Clearly, the sum of the probability of the complementary events equals to 1.'

'Uncle, I was always intrigued by probability. But it seems that if I know the basic concept of probability, this is indeed very fascinating.'

'Yes, whenever you get a problem with probability, frame your question clearly, try to decipher the logic correctly, and finally apply all rules of probability properly to get the answer. Otherwise, it's very easy to get confused!'

'Well, let's go back to the birthday problem. You mentioned that the chance that two friends in a group of 50 will share the same birth date is 97%. Could you please help me calculating the probability in this problem?'

'The problem can be solved using all the ideas that we discussed here like concepts of mutually exclusive events, independent events, complementary events, equally likely events etc. For simplicity, we will only consider the year as a non-leap year which has 365 days, and hence the total number of possible birthdays in the sample space is 365. We also assume that the 365 possible birthdays are equally likely. If P(B) is the probability of at least two friends in your class having the same birthday, it is generally simpler to calculate using the complementary probability P(B'), the probability of there not being any two friends having the same birthday. Let's put the spotlight on you first – you are the first person with a given birthday. We will unfold the logic by first excluding your birthday. Let's start.

The probability that the second friend in your class is *not* sharing the birthday with you is: $P(B_2') = 364/365$. This implies that the second friend's birthday should be in one of 364 days excluding your birthday.

Similarly, the probability that the third friend in your class is *not* sharing the birthday with you and friend 2 is: $P(B_3') = 363/365$.

The probability that the fourth friend in your class is *not* sharing the birthday with three of you is: $P(B_4') = 362/365$.

You can now see the pattern here. For 50 friends in a class, the probability that the fiftieth friend in your class is *not* sharing the birthday with other 49 friends is: $P(B_{50}') = 316/365$.

Now, all these probabilities are independent events (the birthday of any given friend is independent of the birthday of other friends). Hence, we can multiply all these probabilities to obtain the probability that none of these 50 friends share a birthday.

$$P(B_1') \times P(B_2') \times P(B_3') \times P(B_4') \times \ldots\ldots \times P(B_{50}') =$$

$$\frac{365}{365} \times \frac{364}{365} \times \frac{363}{365} \times \frac{362}{365} \times \ldots\ldots \times \frac{316}{365}$$

Denoting this overall probability as $P(B')$, the above expression can be written as:

$$P(B') = \frac{365 \times 364 \times 363 \times 362 \times \ldots\ldots \times 316}{365^{50}}$$

Or in general, for n friends, the simplified expression is:

$$P(B') = \frac{365 \times 364 \times 363 \times 362 \times \ldots\ldots \times (365 - n + 1)}{365^{n}}$$

Finally, we are interested in the event about the occurrence of at least one shared birthday. Then, using the rule of complementary probability, and because B and B' are the only two possibilities and they are also mutually exclusive, we can say that: $P(B) = 1 - P(B')$. Using some simple mathematical calculations, $P(B)$ can be obtained as 0.97, or the probability that two friends will share a birthday in a class of 50 is 97%. In fact, the probability is greater than 99% (almost a certainty) with 58 friends; and this probability is around 50.7% with only 23 friends.'

'Oh, that's very fascinating. That means in a football game, there is more than 50% chance that two persons among the players from teams, the referee and linesmen will have the same birthday.'

'From the probability sense, that's exactly the point!'

'I can now guess the answer to your words problem: mathematically arranging the following words in ascending order: *coin*, *dice* and *card*.'

'Go on Googol.'

'Considering the total number of events in a sample space, the order in ascending order will be: *coin* (2), *dice* (6) and *card* (52). If we consider the probability of each mutually exclusive and equally likely event in the sample space, it will be: *card* (1/52), *dice* (1/6) and *coin* (1/2).'

'Fantastic, full marks to you, Googol.' ■

The tantalizing paradoxes of logic

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Mathematics and logic, historically speaking, have been regarded as entirely distinct studies. However, with tremendous advancement of mathematics in modern times it would be completely inconceivable if one had to regard this discipline as distinct or divorced from logic. In his book titled *Introduction to Mathematical Philosophy*, the great philosopher Bertrand Russell wrote in 1920: "…(L)ogic has become more mathematical and mathematics has become more logical….We find that there is no point at which a sharp line can be drawn with logic to the left and mathematics to the right."

There is ample evidence of the fact, as Russell also seems to indicate, that a close relationship does exist between mathematics and logic. Even a school student, who has studied plane geometry in his mathematics curriculum, is at least mildly aware of this relationship.

In logic, often contradictions arise and these contradictions lead to paradoxes. Of all the problems dealt with in mathematics, paradoxes are perhaps among the most appealing and instructive. The appeal of a paradox arises from the fact that a contradiction comes as a complete surprise in what is generally thought of as the only 'exact' science. And a paradox is always instructive, for unravelling the troublesome line of reasoning requires a close scrutiny of the fundamental principles involved. In fact, many new advances in mathematics have been possible from a thorough investigation of these paradoxes. It would perhaps not be an exaggeration to state that in more recent times, paradoxes have served to bring about revolutionary changes in our ideas concerned with and foundation of mathematics.

The paradox

What actually is a paradox? The word 'paradox', strictly speaking, is not amenable to any precise definition. But, in a broad sense of the term, one may say a paradox is anything which off-hand appears to be false, but is actually true; or which appears to be true but is actually false; or which is simply self-contradictory.

A logical paradox involves three terms of reference. These are self-reference, contradiction, and vicious circle. Take, for instance, the proposition "This sentence has five words." This is self-referential as it refers to itself, but there is no contradiction in the proposition. So, this is not paradoxical. However, in the proposition "This sentence has six words", there is not only self-reference but contradiction too. But, still it falls short of a paradox. In fact, there are forms of self-reference and contradiction of a stronger variety that approach the paradoxical state. A good example of paradox of this type is the notice: 'Please ignore this notice.' To do as it says one must not have done as it says, for in order to ignore the notice one must read it which would then not mean ignoring it. One can next take the well-worn adage "All rules have exceptions." The statement is a rule to the effect that all rules, whatever, have their exceptions. Now, if all rules have exceptions then the particular rule "All rules have exceptions" must also have an exception. One may build up a step by step argument in the following manner:

1. All rules have exceptions.
2. Statement (1) is a rule.
3. Therefore, statement (1) has exception.
4. Therefore, 'all rules do not have exceptions.'

So, the statement "All rules have exceptions" is self-contradictory leading to a paradox.

Elements of paradox

All the above paradoxes, however, lack the third term of description, namely, vicious circularity. The contradictions following the "Please ignore this notice" variety do go round in a circle but do not go round and round. One might say that they are 'not quite paradoxes'; that is, they are circular contradictions lacking vicious circularity. So, circularity and vicious circularity are the elements which govern the distinction between 'not quite paradoxes' and full or complete paradoxes.

An example of a full paradox is furnished by the Bertrand Russell's barber paradox: "A man of Seville is shaved by the barber of Seville if and only if the man does not shave himself. Does the barber of Seville shave himself?"

Does the barber shave himself or doesn't he? Suppose that he does. But a man can be shaved by the barber if he does not shave himself. Therefore, the barber does not shave himself. But, a man who does not shave himself is shaved by the barber. So, the barber does shave himself. The paradox, therefore, goes round and round and provides an excellent example of vicious circularity.

Ancient paradoxes

However, the first and in many ways the best example of a full paradox is the paradox of the liar. Dating back to the 6th century B.C., it was invented by Eubulides, the Greek philosopher and successor to Euclid. In this paradox, Epimenides, the celebrated poet and prophet of Crete, is supposed to have made his famous remark "All Cretans are liars." The statement may off-hand appear to be innocuous. But, one should not forget the crux of the paradox, namely, the fact that Epimenides, who made this statement, is himself a Cretan. If Epimenides is telling the truth, he is lying as he is a Cretan. On the other hand, if he is lying, he is telling the truth. It would perhaps be convenient to put the same argument in a step by step form:

1. All statements made by Cretans are false.
2. Statement (1) was made by a Cretan.
3. Therefore, statement (1) is false.
4. Therefore, 'all statements made by Cretans are not false.'

Obviously, statements (1) and (4) cannot both be true; yet statement (4) follows logically from statement (1). So, statement (1) is self-contradictory.

Another ancient paradox concerns the sophist Protagoras who lived and taught in the 5th century B.C. He made an agreement with one of his pupils whereby the pupil was to pay for his instruction after he had won his first case. However, if he lost, he would not pay. The pupil kept refusing to accept cases. This made Protagoras impatient and so he forced the issue by suing his pupil. Protagoras was sure that his pupil would have to pay him; whereas his pupil was equally sure that he would not have to pay to his instructor. This is how the line of reasoning of both proceeded:

Protagoras: It is going to be this way; either I win this suit or you win it. If I win, you pay me according to the judgement of the court. And if you win, you pay me according to our agreement. In either case I am bound to be paid.

Pupil: It is not so, Sir! If I win, then by the judgement of the court I need not pay you. If, on the other hand, you win then by our agreement I need not pay you. So, in either case I am bound not to have to pay you.

Whose argument was right and whose was wrong? Who can really be the arbiter?

There is yet another dimension of logical paradoxes. Self-reference not only leads to vicious circularity as in the barber paradox above, but can also lead to infinity, the other pole of a paradox. The paradoxes enunciated by the philosopher Zeno of Elea, born around 490 B.C., offer examples of paradoxes of the infinite. The most famous amongst the Zeno's paradoxes is the 'Achilles and the tortoise paradox.' This paradox involves race between Achilles and a tortoise. The argument is that if the tortoise is allowed to start first then Achilles will never be able to overtake him. For, Achilles must always first get to the point from where the tortoise had just departed. So, Achilles cannot overtake the tortoise or indeed catch up with him.

Another paradox of Zeno is the 'Racecourse paradox'. This paradox suggests that motion is impossible. A startling conclusion indeed, nevertheless convincing from the point of view of logic. Let us look at the line of reasoning. Zeno argues that if a man is to walk a distance of one mile, he must first walk half the distance or one-half mile; then he must walk half of what remains or one-fourth mile; then again half of what remains or one-eighth mile; and so on. Thus, an infinite series of finite distances must be successively traversed if the man has to reach the end of the mile. But, an infinite series, by definition, is a series that cannot be exhausted, for it never comes to an end. So, the man can never reach the end of the mile, and seeing that the same argument may be applied *mutatis mutandis* to any finite distance whatever, it is clearly impossible for motion ever to occur.

Paradox of infinity

Another interesting paradox is 'Hilbert hotel paradox', proposed by the German mathematician David Hilbert. Imagine a hotel with a finite number of rooms and assume that all the rooms are occupied. A new guest arrives and asks for a room. Obviously, the proprietor has to disappoint him by regretting his helplessness to offer him a room. Now, let us imagine a hotel with an infinite number of rooms but which are all occupied. To this hotel, too, comes a new guest and asks for a room. "Sure gentleman!" exclaims the proprietor and he moves the person previously occupying room N1 into room N2,the person from room N2 into room N3,the person from room N3 into room N4, and so on. And the new customer receives room N1 which became free as a result of these transpositions.

Let us now imagine a hotel with an infinite number of rooms, all occupied, and an infinite number of new guests who come in and ask for rooms. "Certainly, gentlemen!" says the proprietor, "just wait a minute". He then moves the occupant of room N1 into room N2, the occupant of N2 into N4, the occupant of N3 into N6, and so on. This way all odd-numbered rooms become free and the infinite number of new guests can easily be accommodated in them.

Of the whole string of logical paradoxes, some of them are indeed of considerable importance. The paradoxes torment and tantalize the mind. Besides being thought-provoking, they provide amusement too. They tease a person's imagination and sharpen his logic and ingenuity. Paradoxes, as a matter of fact, have existed for hundreds of years. They were first invented by the early Greek philosophers who used them chiefly to confuse their opponents in debate. Evidently, paradoxes in logic are not just foolish problems with which the philosophically minded while away their time. They have lots of applications too, especially in the field of mathematics. As also remarked in the beginning, they have been instrumental in laying new foundation of mathematics. So, as far as mathematics as a whole is concerned, tremendous advances have resulted from a systematic analysis and investigation of these paradoxes.

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Robert Simson and the line in his name

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One of our objectives during the National Mathematical Year had been to spread awareness about the lives and works of mathematicians of eminence. Robert Simson was one such mathematician. He made many significant contributions in mathematics and one of them relevant for the school going students studying geometry is the Simson's Line.

Robert Simson was born on 14 October 1687; that is, in the same year Newton's *Principia* was published. The year 2012 is his 325th anniversary year, a time to remember this very eminent but forgotten mathematician. Robert was the eldest son of John Simson of Kirktonhall in Ayrshire, Scotland. His parents wanted him to become a clergyman and with that objective he was sent to the University of Glasgow in 1701. There he excelled in classical areas of studies and the sciences.

Robert Simson (1687- 1768)

Robert took great interest in geometry, and mastered the subject on his own. Quite surprisingly, perhaps due to some operational reasons, no lectures were delivered on mathematics in the college. He procured a copy of Euclid's *Elements*, took the help from some more advanced students and got a grip on the subject. Thus the foundation for his higher learning was laid. While mathematics had been his favourite, he was not at all negligent about other subjects. He was quite versatile and people could get a feel of the diversity of this knowledge.

Robert's main strength was mathematics and so phenomenal was his scholarship that in 1710, when he was just above twenty-two years of age, he was offered the mathematical chair, which was going to fall vacant a short time. But out of inherent modesty, he expressed too much reluctance to move abruptly from the state of a student to that of a professor in the same college, at such an early age. So he sought permission to spend at least one year in London for further studies. On obtaining the desired permission, he proceeded to London and left no stone unturned to improve his mathematical knowledge.

At London he got the opportunity of acquainting himself with some contemporary mathematicians of eminence. While still in London, Simson got the professorship of mathematics at the University of Glasgow with the condition that he would have to establish his scholarship in mathematics very much in tune with his capabilities when he was offered the Chair in 1710. He returned to Glasgow and came out with flying colours in the test he had to face. He showed remarkable competence in teaching geometry and algebra and was finally appointed Professor of Mathematics on 20 November, 1711.

Immediately after assuming office, Simson took the initiative of designing schemes of instruction for the students who attended his lectures, in two distinct classes. It was a time when suitable texts were not available for quite a few branches of mathematics. So he embarked on the task of preparing elementary sketches of such areas. Thus began the phase of his career which was fully devoted to the study of mathematics. He had special interest in geometry, but he was equally proficient in other branches of mathematics. He taught for nearly fifty years. He used to teach two separate classes, at different hours, five days a week, during a continued session of seven months.

Memorial to Robert Simson in West Kilbride cemetery. The memorial plate reads: "To Dr. Robert Simson of the University of Glasgow, the Restorer of Grecian Geometry; and by his works, the great promoter of its study in the schools. A Native of this Parish."

From 1758 till his death, Simson maintained a reasonable good health and remained quite active in writing mathematical papers. He took keen interest in solving problems in multiple areas of mathematics and would not even mind to collect such problems from others and took pleasure in demonstration of theorems arising out of them. His articulation on mathematics and allied subjects was characterised by clarity and accuracy of a very high order. However, at some stage he could himself feel that his memory was on the decline. This illness got protracted and prevented him from undertaking the publication of some of his works, which were in an advanced state.

Due to the above said limitation, Simson's only publication, after demitting office was a new and improved edition of Euclid's *Data* which in 1762 was added in the second edition of Euclid's *Elements*. However, there are abundant materials in his printed works and the manuscripts which he had left behind. These were deposited by the direction of his executor in the library of the college at Glasgow. Having said so, it is a matter of regret that only a very small portion of the extensive correspondence which he carried out throughout his life with several distinguished mathematicians have been preserved.

The most remarkable feature of Simson's character was his spirit of inquiry, so much so that almost every object and event caused excitement in him; he would identify a problem related to the situation and would feel quite impatient about finding a solution to it. This, mingled with his sharp intellect and intuitive genius, made him a true researcher in mathematics. He was also an excellent communicator, both through his lectures and his writings. As he was primarily a geometer, there has not been much of a scope to make an assessment of his communication skills from the literary point of view, but a deep introspection into his geometrical demonstrations revealed his attitude towards simplicity and that was also a testimony to his command in language.

However, the most important feature of his character was his humility. He maintained a very high degree of modesty throughout his life. He was quite unassuming and even at times reserved towards spreading awareness about his own works, rather he was found forthcoming in telling people about the contributions made by others. Besides mathematics he had acquired quite a significant knowledge of the sciences, basically using the vehicle of his liberal education, voracious reading, and interaction with learned colleagues irrespective of their disciplines.

Simson never was married and basically remained confined within the four walls of his college, mostly engrossed in his studies. The stringency and strictness of his habits, which indeed pervaded all his occupations, influenced some of his scientific pursuits. He used to budget his time for study, entertainment, and physical exercise with uniform precision. The walks that he took in the squares of garden of the college were all measured by his steps, and he regulated his exercises in accordance with his time or inclination.

Simson maintained good health till the fag end of his life. He got very seriously indisposed only for a few weeks before his death and passed away on 1 October 1768, when he was nearing the completion of his eighty-first year. He bequeathed the small paternal estate in Ayrshire to the eldest son of his next brother, who was professor of Medicine at the University of St. Andrew's and who is known for his works, "Dissertation on the Nervous System, occasioned by the Dissection of a Brain completely Ossified". He left behind a large number of admirers and a great legacy of his works on mathematics, in particular geometry.

Simson's famous works were:

1. Two general propositions of Pappus, in which many of Euclid's Porisms are included.
2. On the Extraction of Approximate Roots of Numbers by Infinite Series.
3. Conic Section
4. The Loci Plani of Apollonius, restored
5. Euclid's Elements
6. Apollonius's determinate section
7. A treatise on Porisms.
8. A tract on Logarithms
9. On the limits of quantities and ratios;
10. Some geometrical problems.

Besides these, his manuscript contained a great variety of geometrical propositions and other interesting observations on different areas of the mathematics, but these were not in a state fit for publication.

Simson's Line

If three perpendiculars are drawn from a point on the circumcircle (a circle that goes through all the vertices of a polygon) of a triangle on its three sides then the feet of the perpendiculars are collinear. This line joining the feet of the perpendiculars is called the 'Simson's Line'.

Proof:

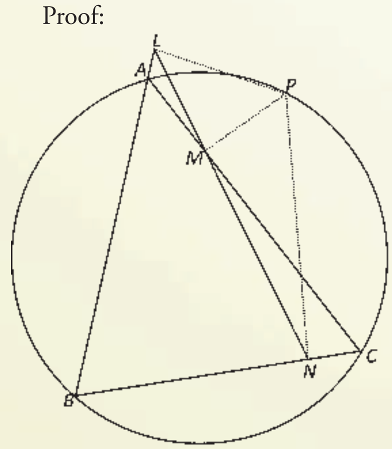

Fig1.

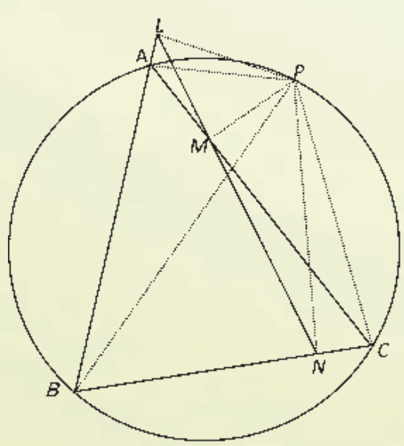

Fig 2

In Fig.1, let *ABC* be a triangle and *P* a point on the circumcircle. Let *L, M, N* be the feet of the perpendiculars from *P* on *BA, AC*, and *CB* respectively. We have to prove that *L, M,* and *N* are collinear. Let us join *LM* and *MN*. We have to prove that *LMN* is a straight angle; that is, equal to 180°.

For arriving at the proof, we shall have to make a series of constructions. First *PA, PB,* and *PC* are joined (Fig. 2).

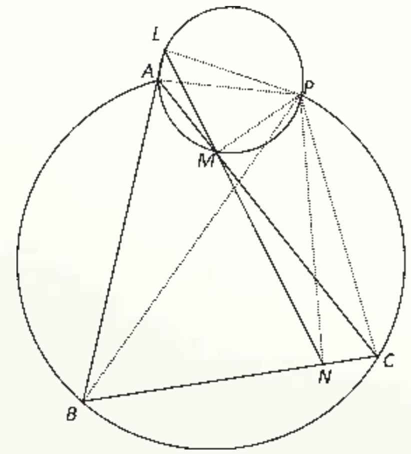

Fig 3

New, we find that angle *ALP* = angle *AMP* = 90°. So, the triangles *AMP* and *ALP* are right-angled. Thus angle *AMP* + angle *ALP*=180°. So, *ALMP* is a cyclic quadrilateral. Moreover, the two right-angled triangles *AMP* and *ALP* have a common hypotenuse *AP*. Therefore *AP* is the diameter of the circle in which the quadrilateral is inscribed.

Now, in Fig.3, the angles *AML* and *APL* are subtended by a common arc at the circumference. So the said angles are equal. Also, since the sum of the angles of triangle *ALP* is 180° and angle *ALP* is 90°, angle *LAP*

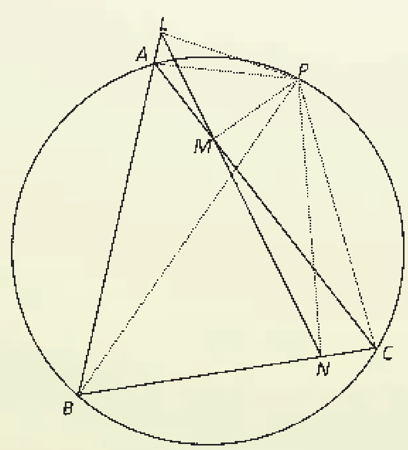

Fig 4.

Continued on page 28

Srinivasa Ramanujan

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The year 2012 marks the 125th birth anniversary of Srinivasa Ramanujan, who is considered one of the greatest mathematicians of the twentieth century. Well-known mathematicians Professors G. H. Hardy and J.E. Littlewood compared Ramajuan's mathematical abilities and natural genius with all-time great mathematicians like Leonhard Euler, Carl Friedrich Gauss, and Karl Gustav Jacobi.

The influence of Ramanujan on number theory is without parallel in mathematics. His papers, problems, and letters would continue to captivate mathematicians for generations to come. He rediscovered a century of mathematics and made new discoveries.

Srinivasa Ramanujan Iyengar (best known as Srinivasa Ramanujan) was born on 22 December 1887, in Erode, about 400 km from Chennai (formerly Madras). Ramanujan's father Srinivasa Iyengar worked as an accountant for a cloth merchant. Ramanujan was the first child born to his mother Komalatammal.

Ramanujan showed a strong inclination towards mathematics from early age and won numerous awards for his calculating skills in elementary school. He passed his primary examination in 1897 and then joined the Town High School.

While at school, Ramanujan came across a book entitled *A Synopsis of Elementary Results in Pure and Applied Mathematics* by George Shoobridge Carr. This book had a great influence on Ramanujan's career. G.H. Hardy (1877 – 1947), an eminent English mathematician wrote about the book: "He (Carr) is now completely forgotten, even in his college, except in so far as Ramanujan kept his name alive". Ramanujan solved all the problems in Carr's *Synopsis*. While working on the problems in the book, he discovered many other new formulae and provided results which were not there in the book. He jotted the results down in a notebook, which he showed to people he thought might be interested. Between 1903 and 1914 he had compiled three notebooks.

G.H. Hardy (1877 – 1947)

Srinivasa Ramanujan (1887 – 1920)

In 1904, Ramanujan entered Kumbakonam's Government College as F.A. student. He was awarded a scholarship. However, after school, Ramanujan's total concentration was focussed on mathematics and he neglected other subjects. As a result he failed and lost his scholarship. During 1906–1912 Ramanujan was constantly in search of a benefactor. Without a university degree it was very difficult for him to find a suitable job and had to struggle financially. Unfortunately he did not have anyone to direct him in his mathematical research. But that did not deter his passion for mathematics and he spent most of his time on mathematics. He noted down his results in his notebooks. These notebooks were his treasures. He looked for a job for livelihood and to support his parents and two brothers. He tutored a few students in mathematics. However, because of his unconventional methods, he was not considered to be a good teacher. Ramanujan's mother Komalatammal was on the lookout for a bride to get her eldest son married. On 14 July, 1909 Ramanujan was married to Janaki.

In 1910 Ramanujan met Professor V. Ramaswami Iyer, an ardent scholar of mathematics and founder of the Indian Mathematical Society. After seeing the notebooks, Professor Ramaswami was convinced that Ramanujan was a gifted mathematician.

Ramanujan's earliest contribution was in the form of question/answer in the *Journal of the Indian Mathematical Society.* Ramanujan proposed 58 questions and their solutions during the period February 1911 to October 1911. The first full-length research paper of Ramanujan, entitled "Some properties of Bernoulli Numbers", appeared in the *Journal of the Indian Mathematical Society* in 1911.

In 1912, Ramanujan secured a job as a clerk in the accounts section of the Madras Port Trust. In the meantime his

Ramanujan (centre) with other scientists at Trinity College

On the occasion of 75th Birth anniversary of Ramanujan, the Indian Philately Association brought out a commemorative stamp in 1962

mathematical work caught the attention of other scholars who recognised his abilities. He was encouraged to contact English mathematicians in the hope that they would be able to assist him. Professor C.L.T. Griffith of Engineering College, Madras, forwarded some of Ramanujan's results on divergent series to Professor M.J.M. Hill of the University of London. Unfortunately, Professor Hill could not study the results in detail and suggested a book and gave advice as to how Ramanujan could get his paper published.

In 1913 Ramanujan wrote a letter to the famous English mathematician G.H.Hardy, who discussed Ramanujan's letter with his collaborator and friend, mathematician John Littlewood (1885–1977). After studying and discussing the letter, both realised that Ramanujan was a world-class mathematician and decided to bring Ramanujan to Cambridge. Ramanujan arrived in London on 14 April 1914. For the next five years, Ramanujan was associated with Hardy. Their collaboration represents the efforts of two great talents. Ramanujan was awarded the B.A. degree by research, in March 1916, for his work on highly composite numbers. He was the first Indian mathematician to be awarded the prestigious Fellowship of the Royal Society, in February 1918. Dr. P.C. Mahalanobis (1893–1972) was a student at King's College, Cambridge during that time and he became a good friend of Ramanujan.

The period of Ramanujan's stay in England almost overlapped with World War–I. During his five-year stay in Trinity College, Cambridge, Ramanujan published 21 research paper, five of which were in collaboration with Hardy. During this time Ramanujan also published short notes in the *Journal of the Indian Mathematical Society.*

After World War-I, Ramanujan returned to India in 1919. After his return from England his health deteriorated and his wife looked after him. Even during those months of prolonged illness Ramanujan kept on jotting down his mathematical calculations and results on sheets of paper. In January 1920, he wrote letter to Hardy and communicated his work on 'mock' theta function. Despite all the tender attention from his wife and the best medical attention from doctors, his health deteriorated. He

Komalatammal, Ramanujan's mother

Janaki, Ramanujan's wife

Infinite series to calculate π

Ramanujan discovered some new infinite series formula in 1910, but their importance was re-discovered around late 1970s, long after his death. One of his elegant formulas was like this:

$$\frac{1}{\pi} = \frac{2\sqrt{2}}{9801}\sum_{k=0}^{\infty}\frac{(4k)!(1103+26390k)}{(k!)^4 396^{4k}}$$

Each addition of a term in Ramanujan's series could give approximately additional eight digits to π. During 1985, about 17 million digits of π were accurately computed by American mathematician William Gosper using this formula. So it also proved the validity of Ramanujan's formula. In 1994, David and Gregory Chudnovsky brothers of Columbia University computed over four billion digits of in a supercomputer using an algorithm which was also similar in essence to the formula given by Ramanujan.

The remarkable Ramanujan and the golden ratio

Srinivasa Ramanujan was a mathematical genius who had the ability look into the depth of mathematics. He created beautiful equations that became humankind's vast storehouse of knowledge. Ramanujan was an expert on infinite series, continued fractions and identities. Ramanujan's equations, once comprehended, unfold beautiful mathematical symmetry.

The following equation demonstrate his artistry

$$\frac{1}{1+\frac{e^{-2\pi}}{1+\frac{e^{-4\pi}}{1+..}}} = \left[\sqrt{\left(\frac{5+\sqrt{5}}{2}\right)} - \frac{\sqrt{5}+1}{2}\right].e^{\frac{2}{5}\pi}$$

What is hidden at the right side of the equation is the golden ratio $(\Phi = \frac{\sqrt{5}+1}{2})$.

Also $\frac{5+\sqrt{5}}{2} = 2 + \frac{\sqrt{5}+1}{2}$

Therefore, if Φ is substituted in the equation, we get the following:

$$\frac{1}{1+\frac{e^{-2\pi}}{1+\frac{e^{-4\pi}}{1+..}}} = \left(\sqrt{2+\Phi} - \Phi\right).e^{\frac{2}{5}\pi}$$

The expression includes an infinite continuing fraction, e, π and the golden ratio (Φ). It is interesting to see how the golden ratio inevitably placed itself in one of the equations of the greatest mathematician of twentieth century.

breathed his last on 26 April 1920, at the age of 32.

After Ramanujan's death, Hardy tried systematic verification of Ramanujan's results from the second notebook. However, it was a daunting task and he persuaded the University of Madras to undertake the task. In 1931, the University of Madras requested Professor G.N. Watson to edit the notebooks in a suitable form for publication. This was a formidable task, since the notebooks contained over 300 theorems. Watson undertook the task of editing the notebooks with Professor B.M. Wilson. Unfortunately, Wilson passed away in 1935, virtually marking the end of the efforts to edit the notebooks.

The collected edition of Ramanujan's works was later edited by Hardy. The first edition of this book was published in 1927 by Cambridge University Press. This resulted in a flurry of research papers during the period 1928–38. In 1999, the American Mathematical society and London Mathematical Society reprinted the collected papers.

Much of Ramanujan's mathematics falls in the domain of number theory — the purest realm of mathematics. During his short lifetime, Ramanujan independently compiled nearly 3,900 results (mostly identities and equations). He stated results that were both original and highly unconventional, such as the Ramanujan prime and the Ramanujan theta function, and these have inspired a vast amount of further research in mathematics.

As Robert Kanigel says ".....few can say much about his work, and yet something in the story of his struggle for the chance to pursue his work on his own terms compels the imagination, leaving Ramanujan a symbol for genius, for the obstacles it faces, for the burdens it bears, for the pleasure it takes in its own existence."

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Continued from page 31 (Robert Simson and the line in his name)

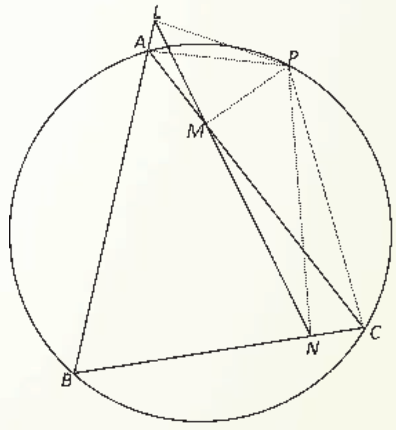

Fig 5.

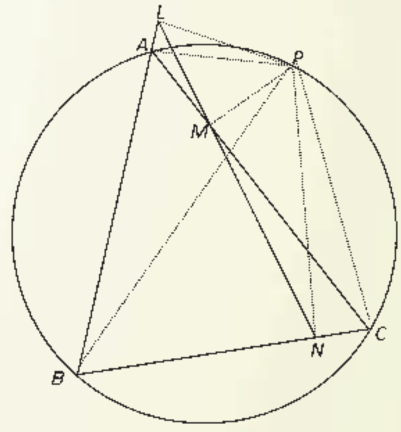

Fig 6.

and *LPA* are complementary.

The angles *CMN* and *CPN* are subtended at the circumference by the same arc *CN*. So, angle *CMN* = angle *CPN*. Also since the sum of the angles of triangle *CNP* is 180°, and angle *CNP* is 90°, the angles *NPC* and *NCP* are complementary.

Now, refer to Fig. 5. Since point *P* lies on the circumcircle of triangle *ABC*, the quadrilateral *APCB* is cyclic. Therefore opposite angles *BAP* and *BCP* are supplementary; i.e., angle *BAP* + angle *BCP* = 180°. Again, angle *BAP* + angle *LAP*=180°.

∴ Angle *BCP* = angle *LAP*

Now, refer to Fig. 6. Since angles *BCP* and *NCP* are the same, it follows that angles *LAP* and *NCP* are equal. Since angles *LAP* and *LPA* are complementary, and angles *NCP* and *NPC* are complementary. So angles *LPA* and *NPC* are complementary to equal angles, and so angle *LPA*= angle *NPC*.

Now, angle *LPA* = angle *LMA*

And angle *NPC* = angle *NMC*

∴ angle *LMA* = angle *NMC*

But *AC* is a straight line

∴ *AMC* is a straight angle

∴ angle *AMC* = 180°

∴ angle *LMC* = 180°– angle *LMA*

Or angle *LMC* = 180° – angle *NMC*

∴ angle *LMC* + angle *NMC* = 180°

∴ angle *LMN* = 180° = A straight angle.

Hence the proof.

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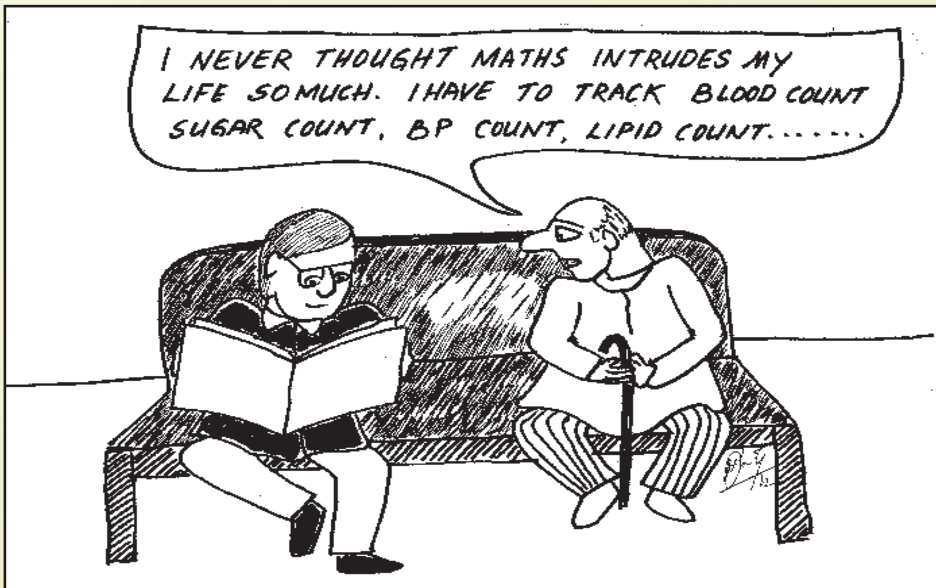

Cartoon by : V.S.S. Sastri E-mail: vsssastri@gmail.com

Science Nobel Prizes 2012

Biman Basu
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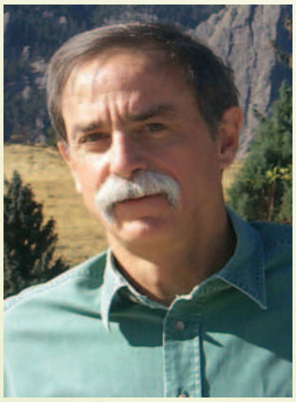
The Nobel Prizes in science for the year 2012 have been shared by six scientists – three Americans, one French, one English, and one Japanese. Their work ranges from research concerning the bizarre world of quantum optics that may revolutionise measurement of time to cellular receptors involved in different physiological processes and research on stem cells.

Physics

The 2012 Nobel Prize in Physics has been awarded jointly to the French-American duo of Serge Haroche and David Wineland for inventing methods to observe the bizarre properties of the quantum world, The Nobel citation said the award was for "ground-breaking experimental methods that enable measuring and manipulation of individual quantum systems". Their ground-breaking methods have enabled this field of research to take the very first steps towards building a new type of superfast computer based on quantum physics.

Serge Haroche



David Wineland

Haroche is based at the College de France in Paris while David Wineland is with the US National Institute for Standards and Technology in Boulder, Colorado. Their research has opened the door to new experiments in quantum physics by showing how to observe individual quantum particles without destroying them. It has also led to the construction of extremely precise clocks that could become the future basis for a new standard of time and helped scientists take the first steps toward building superfast computers.

Quantum optics is the field that deals with the interaction between light and matter. Both physicists work in the field of quantum optics, studying the fundamental interaction between light and matter, a field which has seen considerable progress since the mid-1980s. In their work, Wineland traps electrically charged atoms, or ions, controlling and measuring them with light, or photons. Haroche takes the opposite approach: he controls and measures trapped photons, or particles of light, by sending atoms through an ion trap. Working with light and matter on this level would have been unthinkable before the two scientists developed solutions to pick, manipulate and measure photons and ions individually, allowing an insight into a microscopic world that was once just the province of scientific theory. Through "ingenious laboratory methods," the two scientists have managed to measure and control fragile quantum states that were previously thought to be impossible to observe directly. The Nobel-winners' work on single photons and charged atoms has thus opened up a whole new field of study in physics.

Chemistry

The 2012 Nobel Prize in Chemistry has been awarded jointly to two US researchers, Robert Lefkowitz and Brian Kobilka for their work that shed light on how the billions of cells in our body sense their environments. Lefkowitz works at the Howard Hughes Medical Institute in Maryland. Kobilka joined Lefkowitz at HHMI in the 1980s, but is now at Stanford University in California.

Robert Lefkowitz

Brian Kobilka

Their work focuses on what are called G-protein-coupled receptors (GPCRs), which constitute a large and diverse family of proteins whose primary function is to convert extracellular stimuli into intracellular signals by crossing cell membranes. Understanding how they work has been crucial to unravelling the complex network of signalling between cells. The rush of adrenaline hormone one gets when scared is just one manifestation of this vast network, communicating a chemical signal across billions of cells through otherwise impenetrable cell membranes.

In the field of biochemistry, a receptor is a molecule most often found on the surface of a cell, which receives chemical signals originating outside the cell. Through binding to a receptor, these signals direct a cell to do something – for example to divide or die, or to allow certain molecules to enter or exit.

At the end of the 19th Century, when scientists began experimenting with adrenalin's effects on the body, they discovered that it makes the heart rate and blood pressure increase and also relax the pupils of the eye. They suspected that adrenalin worked via nerves in the body. To prove it, they paralysed the nervous system of laboratory animals. However, the effect of the adrenalin still manifested itself, which indicated that cells must have some kind of receptor that enables them to sense chemical substances – hormones, poisons and drugs – in their environment.

But when researchers attempted to find these receptors, they hit the wall and the receptors remained unidentified for decades till two different types of receptors called alpha and beta receptors were identified in the 1940s. Soon after this, scientists developed the first beta blockers, which are currently some of our most frequently used heart medicines. The work of this year's Nobel laureates has further helped explaining how receptors work.

The human body has about 1,000 kinds of receptors – structures on the surface of cells, which let the body respond to a wide variety of chemical signals, like adrenaline. The receptors in the nose, tongue and eyes let us sense smells, tastes and light.

In the late 1960s, Lefkowitz started investigating the receptors by following the movement of radioactive isotopes attached to hormones within cells, trying to track down how signals get through cell membranes. Kobilka's work in the 1980s helped researchers realise that there is a whole family of receptors that look alike – a family that is now called G-protein-coupled receptors. In 2011, Kobilka achieved another breakthrough when his team captured an image of the receptor for adrenaline at the moment when it is activated by a hormone and sends a signal into the cell.

The groundbreaking work of this year's laureates, spanning genetics and biochemistry, has laid the basis for much of our understanding of modern pharmacology as well as how cells in different parts of living organisms can react differently to external stimulation, such as light and smell, or the internal systems which control our bodies such as hormones. The knowledge of the structure of G-protein coupled receptors has revolutionised our understanding of how they work as small 'molecular machines' and will lead to enormous advances in drug design.

In recent years, the mapping of the human genome has revealed close to a thousand genes that code for GPCRs. About half of those receptors receive odours and are part of the olfactory system. A third of them are receptors for hormones and signalling substances, such as dopamine, serotonin, prostaglandin, glucagon, and histamine. Some receptors capture the light that hits the eye, while others are located on the tongue and give us our sense of taste. Over one hundred receptors still present challenges to scientists, as their purposes have yet to be figured out.

Physiology or Medicine

The 2012 Nobel Prize for Physiology or Medicine has been awarded jointly to John B. Gurdon of the University of Cambridge in England and Shinya Yamanaka of Kyoto University in Japan for their discovery that mature cells can be reprogrammed to become immature cells capable of developing into all tissues of the body. Their findings have revolutionised our understanding of how cells and organisms develop.

The human body is made up of a large variety of cells – blood, skin, hair, bone, nerve, muscle, and many others – each of which is highly specialised, but develop from a single kind of cells – embryonic stem cells. All humans develop from fertilised egg cells. During the first days after conception, the embryo consists of immature cells called embryonic stem cells, each of which is capable of developing into all the cell types that form the adult organism. Such cells are called pluripotent stem cells. With further development of the embryo, these cells give rise to nerve cells, muscle cells, liver cells and all other cell types – each of them specialised to carry out a specific task in the adult body. Although there are stem cells for different tissues such as skin, blood, bone, etc., which become active to grow new tissue to heal injuries or give rise to new blood cells, only embryonic stem cells have the capacity to grow into all types of body cells.

For a long time it was believed that mature cells such as skin cells cannot be made to grow into any other kind of body cell the way embryonic stem cells can be. But in 1962, Gurdon discovered that the specialisation of cells is reversible. In a classic experiment, he extracted the cell nucleus, containing the frog's DNA, from a mature intestinal cell and injected the nucleus into a frog egg whose own nucleus had been removed. The egg was evidently able to reprogram the introduced nucleus and direct its genes to switch from the duties of an intestinal cell to those appropriate to a developing egg. The modified egg cell ultimately developed into a normal tadpole, demonstrating that

John B. Gurdon

Shinya Yamanaka

the DNA of the mature cell still had all the information needed to develop all cells in the frog. Gurdon's landmark discovery was initially met with scepticism but became accepted when it had been confirmed by other scientists. It initiated intense research and the technique was further developed, leading eventually to the cloning of mammals.

More than 40 years later, in 2006, Yamanaka discovered how intact mature cells in mice could be reprogrammed to become immature stem cells. His research concerned embryonic stem cells, i.e., pluripotent stem cells that are isolated from the embryo and cultured in the laboratory. Such stem cells were initially isolated from mice by Martin Evans (Nobel Prize 2007) and Yamanaka tried to find the genes that kept them immature. When several of these genes had been identified, he tested whether any of them could reprogram mature cells to become pluripotent stem cells. He found, by introducing only a few genes, he could reprogram mature cells to become pluripotent stem cells.

Yamanaka and his co-workers introduced these genes, in different combinations, into mature cells from connective tissue, fibroblasts, and examined the results under the microscope. They finally found a combination that worked, and the recipe was surprisingly simple. By introducing four genes together, they could reprogram their fibroblasts into immature stem cells. The resulting induced pluripotent stem cells (also known as iPS cells) could develop into mature cell types such as fibroblasts, nerve cells, and gut cells.

These groundbreaking discoveries have completely changed the prevalent view of the development and cellular specialisation. It is now clear that the mature cell does not have to be confined forever to its specialised state. By reprogramming human cells, scientists have created new opportunities to study diseases and develop methods for diagnosis and therapy.

Of Gyms, Muscle-building Drugs and More

Knowing the risks

Dr Yatish Agarwal
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The lure of the gold can demonise the best. Be it a mining prospector, sportsperson, or the man on the street. Even as Indian metros and bigger towns get swamped by home-grown gyms and gym-masters, and cine stars flaunt their six abs and size zero, young people and adults hunt for easy options to wear that swell look. The use of muscle-building supplements and performance-enhancing drugs stems from that. Step into any of the *desi* gyms and sport coaching centres, and you would have ill-informed diabolical gurus offering you pills, powders and shots of the forbidden.

Let that not be the mantra you take. Use of performance-enhancing drugs — aka, doping — carries serious risks. Let's look at how these drugs work and how they can affect your health. Let's see their professed benefits, the health risks and the many unknowns.

The range of these so-called performance-enhancing drugs is far and wide. They include such compounds as anabolic steroids, androstenedione, human growth hormone, erythropoietin, diuretics, creatine, and stimulants.

Anabolic steroids

Some people take a form of steroids — known as anabolic-androgen steroids or just anabolic steroids — to increase their muscle mass and strength. The main anabolic steroid hormone produced in the human body is testosterone.

Testosterone

Testosterone has two main effects on the body: One, anabolic effects promote muscle building; and two, androgenic effects are responsible for male traits, such as facial hair and a deeper voice.

Some people take straight testosterone to boost their sporting performance. Frequently, the anabolic steroids that athletes use are synthetic modifications of testosterone. These hormones have approved medical uses, though improving athletic performance is not one of them. They can be taken as pills, injections or topical treatments.

Designer steroids

A particularly dangerous class of anabolic steroids are the so-called "designer" drugs — synthetic steroids that have been illicitly created to be undetectable by current drug tests. They are made specifically for young people and athletes and have no approved medical use.

The bait

Why are these drugs so appealing? Besides making muscles bigger, anabolic steroids may help you recover from a hard workout more quickly by reducing the muscle damage that occurs during the session. This enables you to workout harder and more frequently without overstraining. In addition, some people may like the aggressive feelings they get when they take the drugs.

Risks

Anabolic steroids come with serious physical side effects. Men may develop prominent breasts, baldness, shrunken testicles, prostate gland enlargement and infertility. Similarly, women may develop a deeper voice, increased body hair, and baldness. Both men and women might experience severe acne, but even more significantly, they are at an increased risk for developing tendinitis and tendon rupture, liver abnormalities and tumours, increased "bad" cholesterol [low-density lipoprotein (LDL)], decreased "healthy" cholesterol [high-density lipoprotein (HDL)], hypertension, heart and circulatory problems, suppression of the hypothalamic-pituitary-gonadal axis, which is a critical part in the development and regulation of a number of the body's systems, such as the reproductive and immune systems. Fluctuations in the hormones cause changes in the hormones produced by each gland and have various widespread and local effects on the body. Use of anabolic steroids can also lead to aggressive behaviours, rage or violence, and psychiatric disorders, such as depression.

You also run the risk of developing drug dependence. If you're injecting the drugs, you might end up with serious infections or diseases such as HIV or hepatitis. In teenagers, their use can inhibit growth and development, and can spawn serious health problems in the future.

Taking anabolic-androgenic steroids to enhance athletic performance, besides being prohibited by most sports organisations, is illegal.

Androstenedione

Androstenedione (andro) is a hormone produced by the adrenal glands, ovaries and testes. It's a hormone that's normally converted to testosterone and estradiol in both men and women.

Andro is available in prescription and nonprescription forms. The prescription version is a controlled substance. Andro is also sold without a prescription as a nutritional supplement. Manufacturers and bodybuilding magazines tout its ability to allow athletes to train harder and recover more quickly. However, its use as a performance-enhancing drug is illegal.

Scientific studies that refute these claims show that supplemental androstenedione does not increase testosterone and that your muscles don't get stronger with andro use. In fact, almost all of the andro is rapidly converted to estrogen, the primary hormone in females.

Risks

Side effects of andro in men include acne, enlargement of the breasts, shrinking of the testicles, and diminished sperm production. In women, side effects include acne and masculinisation, such as deepening of the voice and male-pattern baldness. In both men and women, andro can decrease HDL cholesterol (the "good" cholesterol), which puts you at greater risk of heart attack and stroke.

Human growth hormone

Human growth hormone is a hormone that has an anabolic effect. People take it to improve muscle mass and performance. However, it has not been shown conclusively to improve either strength or endurance. It is available only by prescription and is administered by injection.

Risks

Human growth hormone can cause serious adverse effects. This may include joint pains, muscle weakness, fluid retention, carpal tunnel syndrome, which causes pain, tingling, and other problems in your hand because of pressure on the median nerve that runs the length of the arm, passes through the wrist, and ends in the hand. HGH also causes impaired glucose regulation leading to diabetes, hyperlipidemia, and cardiomyopathy.

Erythropoietin

Erythropoietin is a type of hormone used to treat anaemia in people with severe kidney disease. It increases production of red blood cells and haemoglobin, resulting in improved movement of oxygen to the muscles. Epoetin, a synthetic form of erythropoietin, is commonly used by endurance athletes.

Risks

Erythropoietin use among competitive cyclists was common in the 1990s and allegedly contributed to at least 18 deaths. Inappropriate use of erythropoietin may increase the risk of thrombotic events, such as stroke, heart attack and pulmonary edema.

Diuretics

Diuretics are water-pills. They change your body's natural balance of fluids and salts (electrolytes) and can lead to dehydration. This loss of water can decrease a person's weight, helping him or her to compete in a lighter weight class, which many athletes prefer. Diuretics may also help athletes pass drug tests by diluting their urine and are sometimes referred to as a "masking" agent.

Risks

Diuretics taken at any dose, even medically recommended doses, predispose athletes to adverse effects such as dehydration, muscle cramps, exhaustion, dizziness, potassium deficiency, heart arrhythmias, drop in blood pressure, heatstroke, and death.

Creatine

Many people take nutritional supplements instead of or in addition to performance-enhancing drugs. Supplements are available over-the-counter as powders or pills.

The most popular supplement among athletes is creatine monohydrate. Creatine is a naturally occurring compound produced by your body that helps your muscles release energy.

Scientific research indicates that creatine may have some athletic benefit by producing small gains in short-term bursts of power. Creatine appears to help muscles make more adenosine triphosphate (ATP), which stores and transports energy in cells, and is used for quick bursts of activity, such as weightlifting or sprinting. There is no evidence, however, that creatine enhances performance in aerobic or endurance sports.

Your liver produces about 2 grams of creatine each day. If you prefer to eat meat, you also get creatine in your diet. Creatine is stored in your muscles, and levels are relatively easily maintained. Since your kidneys remove excess creatine, the value of supplements to someone who already has adequate muscle creatine content is questionable.

Risks

Supplements are considered food and not drugs by the FDA. This means supplement manufacturers are not required to conform to the same standards as drug manufacturers do. In some cases, supplements have been found to be contaminated with other substances, which may inadvertently lead to a positive test for performance-enhancing drugs.

Possible side effects of creatine that can decrease athletic performance include stomach cramps, muscle cramps, nausea, diarrhoea and weight gain. Weight gain is sought after by athletes who want to increase their size. But with prolonged creatine use, weight gain is more likely the result of water retention than an increase in muscle mass. Water is drawn into your muscle tissue, away from other parts of your body. This puts you at risk of dehydration. High-dose creatine use may potentially damage your kidneys, and liver.

It appears safe for adults to use creatine at the doses recommended by manufacturers. But it is unknown what kind of effect taking creatine has over the long term, especially in teens and children.

Stimulants

Some people use stimulants to stimulate the central nervous system and increase heart rate and blood pressure. Stimulants can improve endurance, reduce fatigue, suppress appetite and increase alertness and aggressiveness.

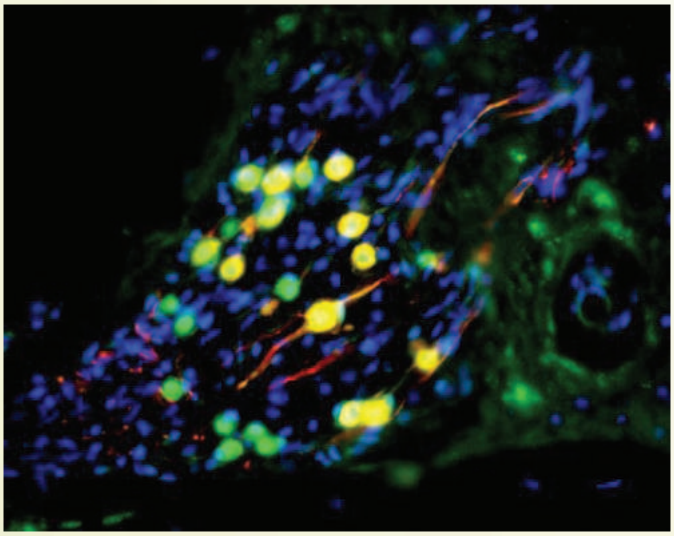
Common stimulants include caffeine and amphetamines. Cold remedies often contain the stimulants ephedrine or pseudoephedrine hydrochloride. The street drugs cocaine and methamphetamine also are stimulants.

Continued on page 21

Recent developments in science and technology

Human stem cells restore hearing in rodents

Hearing impairment occurs when there is a problem with or damage to one or more parts of the ear. The degree of hearing impairment can vary widely from person to person. Some people have partial hearing loss, meaning that the ear can pick up some sounds; others have complete hearing loss, meaning that the ear cannot hear at all (people with complete hearing loss are considered deaf). According to World Health Organisation, about 250-300 million people in this world have moderate-to-profound hearing loss, and many of those cases are caused by a breach in the connection between the inner ear and the brain. In India, one out of twelve persons suffers from hearing loss.



Neurons (in yellow) derived from human embryonic stem cells have restored hearing to deaf gerbils. (Credit: Marcelo Rivolta, University of Sheffield)

Treatment for temporary or reversible hearing loss usually depends on the cause of the hearing loss. Treatment for reversible hearing loss depends on its cause. It is often treated successfully by medicine or surgery. In permanent hearing loss, such as age-related and noise-induced hearing loss, hearing devices can often improve how well a person hears and communicates. Hearing aids make sounds louder, but they do not restore hearing; they may only help a person function and communicate more easily. Several types of hearing implants such as a cochlear implant are available, each for specific types of hearing problems.

Cochlear implants can help patients who have lost or damaged hair cells – the first sensory cells in the pathway that make hearing possible – but they don't work if patients have also lost the neurons (nerve cells) that transmit the auditory information to the brain. Recently, researchers have restored hearing in deaf rodents using human embryonic stem cells, demonstrating for the first time that these cells can replace missing or damaged neurons in the nervous pathway that makes hearing possible. A team of researchers at the University of Sheffield, UK, led by Marcelo Rivolta could partially restore the hearing of deaf gerbils with injections of nerve cells created from human embryonic stem cells (*Nature*, 12 September 2012 | doi:10.1038/nature.2012.11402). The study offers the first proof that stem cells can reconnect inner ear to brain.

During the past decade Rivolta has been engaged developing ways to differentiate human embryonic stem cells into the two cell types that are essential for hearing: auditory neurons, and the inner-ear hair cells that translate sound into electrical signals. By treating human embryonic stem cells with two types of fibroblast growth factor (FGF), he could produce two, visually distinct, groups of primordial sensory cell. One group had characteristics similar to hair cells found in inner ear, and the other group looked more like neurons.

The researchers then transplanted the neuron-like cells into the ears of gerbils that had been treated with a chemical that damages auditory nerves, but not hair cells. This meant the treated gerbils had damaged neurons but intact hair cells. Ten weeks after the transplant, some of the transplanted cells had grown projections that formed connections to the brain stem. Subsequent testing showed that many of the animals could hear much fainter sounds after transplantation, with an overall improvement in hearing of 46%.

According to the researchers, the number of people who might benefit from a stem-cell-driven increase in auditory neurons remains unclear, but stem cells could broaden the reach of existing therapies. However, the first treatments for hearing in humans could take at least 15 years to develop.

Ancestry of human blood groups

The blood group is an essential characteristic of an individual that decides his or her suitability as a donor or recipient of blood transfusion. The most well-known and medically important blood types are in the ABO group. They were discovered in 1900 and 1901 at the University of Vienna by Karl Landsteiner in the process of trying to learn why blood transfusions sometimes cause death and at other times save a patient. Apart from the ABO groups there are other factors such as the Rh factor that are used to characterise blood type. Recent research suggests that the A, B and O blood types in people evolved at least 20 million years ago in a common ancestor of humans and other primates. The study was reported online by Laure Ségurel of the University of Chicago and colleagues on 22 October in the *Proceedings of the National Academy of Sciences* (doi: 10.1073/pnas.1210603109).

Ségurel and colleagues analysed genetic data on ABO blood types for various primate species. Then they looked at a particular stretch of DNA in the blood type gene in humans, bonobos, chimpanzees, gorillas, orangutans and several species of monkey and compared that stretch of DNA across species on the larger primate family tree. The pattern they saw suggests that the A and B blood groups were around at least 20 million years ago, well before the chimphuman split, and probably as far back as the common ancestor of humans and old-world monkeys.

It was known from past research that the two amino acids responsible for A and B blood types are identical in humans, orangutans, gibbons, macaques, and baboons. The latest analysis reveals that a more evolutionarily distant new world monkey shares the same genetic basis for this blood group. This implies that blood types likely first emerged in a distant primate ancestor and have persisted for millions of years in humans and gibbons, as well as among old world monkey species. As a consequence, in a small region of the genome, a human with an A blood group is more similar to a gibbon of type A than to a human of type B.

The finding counters the theory that blood types evolved independently in each primate species. The biological significance of the different blood types, besides their role in transfusions, however, remains unclear. Because they appear to be associated with infectious diseases, blood types could play a key role in immune response, according to the authors.

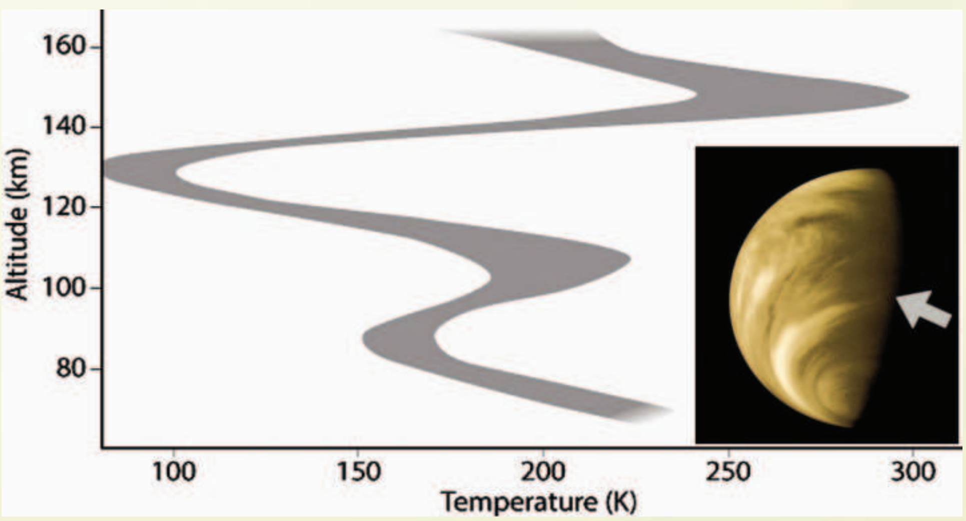
Strange cold layer of Venus

With an average temperature of 464°C, Venus has been known to be the hottest planet of the solar system. Its dense carbon dioxide atmosphere is believed to be the cause, leading to a runaway greenhouse effect that has made the planet scorching hot. But a new study has revealed that Venus's atmosphere also has regions that are chilling cold at temperatures around minus 175 degrees Celsius, colder than any part of our own planet's atmosphere. The strangely cold region lies about 125 kilometres above the planet's surface and exists along the planet's terminator, the dividing line between the day and night sides of Venus.

The surprising discovery was made by European Space Agency's *Venus Express* spacecraft, which has been orbiting Venus since April 2006. ESA scientists discovered the cold layer by measuring the concentration of carbon dioxide gas molecules at various altitudes along the dividing line between day and night on Venus (called the terminator). Combing these data with the known atmospheric pressure at each height, the researchers were able to derive the temperatures of various layers of the planet's atmosphere.

According to ESA scientists, this region may be cool enough for carbon dioxide snow or ice to form. The cold layer is sandwiched between warmer layers on both sides. The finding is very new and a similar temperature profile is not seen along the terminator in the atmospheres of Earth or Mars, which have different chemical compositions and temperature conditions.

According to the scientists, if there is ice or snow made of carbon dioxide there, it should be very reflective, creating especially bright spots on Venus. *Venus Express* indeed occasionally observes very bright regions in the Venusian atmosphere that could be explained by ice. The spacecraft is slated to continue operating through at least 2014. ■



The temperature profile along the terminator (inset, shown by arrow) for altitudes of 70–160 km above the surface of Venus.

Letters to the editor

Operation Zero

I am a science teacher in Udala High School. I am a regular reader of Dream 2047. After going through the article "Operation Zero" by Rintu Nath in the September issue I came to know so many things about zero.

Mrutyunjay Mehanty,
Science Teacher, Udala Govt. High School, Udala, Odisha

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Informative articles

I was delighted to receive a copy of the September 2012 issue of Dream 2047. The Editorial on "Curiosity" was quite informative. The articles on "Zero" by Rintu Nath and on "Higgs boson" by V.B. Kamble were also informative. I also liked the write-up on "Electronic Sensor" in 'Recent Developments in Science and Technology'.

I would request to increase the number of pages devoted to Letters. Also, upcoming VP programmes could be announced on the VP website to enable those interested to attend such events or get in touch with VP. Once I missed a chance to attend a conference held at Dhenkand because I came to know about it when it was over. Please include a list of such programmes at least one month in advance on the website.

Dr. Anup Pattanaik
Lecturer in Physics, IGIT
Sarang, Odisha - 768019

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This is in response to the article "Remembering Ruchi Ram Sahani" of Nov 2012 issue. The article is very informative and covers many facts which is unknown. Prof. Sahani contributed a lot for popularizing science in the basic level. Some facts like he worked in the lab of Lord Rutherford and Niels Bohr was his research colleague will make us proud. His work should be popularized so that many would follow his footsteps.

Dr. Asit Parija
Lecturer, Department of Chemistry,
Salipur College, Odisha.

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Workshop on Capacity Building of Teachers' Pedagogical Concerns: Popularisation of Science

Vigyan Prasar (VP), in collaboration with Society for Educational and Social Development (SESD) and Central Institute of Education (CIE), University of Delhi, organised a three-day workshop on "Capacity Building of Teachers' Pedagogical Concerns: Popularisation of Science" in Delhi during 26–28 July 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. Fifty teachers and science communicators attended the workshop.

The workshop was inaugurated by Professor K. Kannan, Dean, Biotechnology, Guru Gobind Singh Indraprastha University. In his inaugural address Professor Kannan emphasised the role of teachers in popularising science. He said whatever is learnt in science should be linked to daily life. Dr. Subodh Mahanti, Scientist 'G', VP, shared Vigyan Prasar objectives. He mentioned that one of the roles of Vigyan Prasar is to develop low-cost resource materials and make it available to schools and community. In the context of IYC 2011, he explained the role of chemistry in everyday life. Professor R.P. Sharma. Former Head and Dean, University of Delhi emphasised that scientific method should be applied to all spheres of life; science provides an orderly approach to solving problems of everyday life. Professor U.S. Sharma, formed Head and Dean (Education), University of Delhi and President, SESD welcomed all the participants and mentioned inter-institutional collaboration for organising the workshop. Dr. Nirupma Jaimini, Professor, CIE, gave a brief outline of the three-day workshop.

A brainstorming session was organised on the theme "Sensitising teachers in popularising science". Professor Gurmeet Singh, Department of Chemistry, Delhi University, chaired the session. Dr Alka Behari, CIE, mentioned that there is a need to develop and integrate level based competencies in science teaching. The anchoring pillars for these competencies are subject knowledge and pedagogical concern. Dr Vandana Saxena, CIE, said that teachers should develop versatility in their methods of teaching science while addressing students in the classroom. Shri Rintu Nath, Scientist – 'E', VP, discussed initiatives of Vigyan Prasar in developing contents in the form of books, interactive CDs, and hands-on activities using kits, audio and video programmes. He explained that teachers trained during the workshop will act as resource persons to disseminate similar activities in their own sphere of work. He said, resources developed by VP are supplementary teaching materials for understanding and appreciating science. Dr Shankar Chowdhury, UNESCO, talked about the need to develop knowledge society. He stressed that community radio can be used to popularise science. Dr. Rumesh Chander, CIE, talked about the provisions for teachers to share their experience with their fellow teachers within the school and the neighbourhood schools. Ms Harsh Kumari, Head Mistress, CIE Experimental School, explained the need to focus on children's idea and allow them to explore learning by doing. Ms. Suman Nath, Principal, Tagore International School, stressed on the importance of hands-on activities.

The brainstorming session brought out pedagogical and community related dimensions in popularising science vis-à-vis the role of various stake holders. Five groups were formed to evolve an outline of the action plans. Dr. Alka Beharee, Dr. Vandana Saxena, Dr. Shankar Chowdhury, Ms. Puneeta Malhotra, Dr Subhash Chander, and Ms Hansh Kumari facilitated in preparing the action plan.

On day 2, Professor H.O. Gupta, former head, science workshop, NCERT, demonstrated several experiments on chemistry. Shri Kapil Tripathi, Scientist 'D', VP, demonstrated a few kits developed by VP. Participants did hands-on activities using the chemistry kit provided by VP.

On day 3, participants were taken to National Science Centre and the first half of the day was spent in visiting the science and technology galleries and interaction with the National Science Centre team. In the second half, presentations were made by the participants. A few participants shared their views on the workshop and explained how it would help them in utilising the resource materials provided by VP in doing hand-on experiments. Er. Anuj Sinha, former head, National Council for Science and Technology Communication, Govt. of India, was the chief guest of the valedictory session. He mentioned that development is occurring at a very fast rate. Effective teaching and learning becomes essential to keep pace with the new changes around the globe. Prof. S.K. Thakur, former chairperson, National Council for Teacher education (NCTE), chaired the session. He said that a small child is attracted to the subject when the teacher's persona attracts him/her. Therefore teachers can help developing interest in a subject.

(Report: Rintu Nath) ■

Continued from page 24 **(Of Gyms, Muscle-building Drugs and More...)**

Risks

Although stimulants can boost physical performance and promote aggressiveness on the sporting field, they have side effects that can impair athletic performance. They tend to make you nervous and irritable, thus making it hard to concentrate on the game. They can make you insomniac and prevent you from getting needed sleep. You also run the risk of developing dehydration and heatstroke.

You may also become psychologically addicted or develop a tolerance. When that happens, you need greater amounts to achieve the desired effect, meaning you will take doses that are much higher than the intended medical dose.

Other side effects include heart palpitations, heart rhythm abnormalities, weight loss, tremors, mild hypertension, hallucinations, convulsions, stroke, and heart attack and other circulatory problems.

No matter how you look at it, using performance-enhancing drugs is a risky business. It is best to stay out of the harm's way. Whatever the gym gurus or your seniors may say, never risk your life on them. ■