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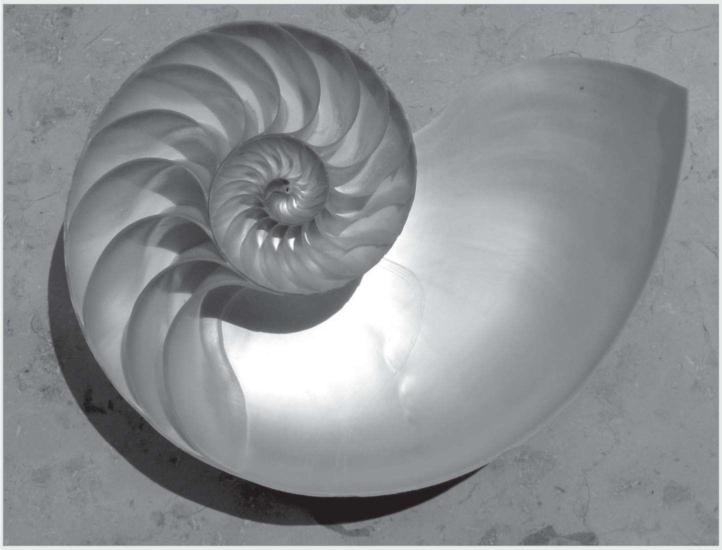

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website : http://hsb.iitm.ac.in/~jm

Brain Teasers

1. At the recent jam making contest, four lucky candidates took part to make the juiciest strawberry jam. The ages of the contestants were 14, 17, 20 and 22.

As it happens the person who came last was the oldest, whereas Sri was three years older than the person who came second.

Jana was neither the oldest nor the youngest and Kalyan finished ahead of the 17 year old, but didn't win.

Jolly was also unlucky this time and didn't win either.

Can you determine who finished where and how old they are?

2. Place all of the digits from 1 to 9 into the circles (see figure on next page) so that the sum of the numbers in each straight line is the same.

From brainbashers.com

Answers to last issue's Brain Teasers

1. *After a local Post Office burglary, five suspects were being interviewed. Below is a summary of their statements.*

Brian said: It wasn't Charles; It was Alan

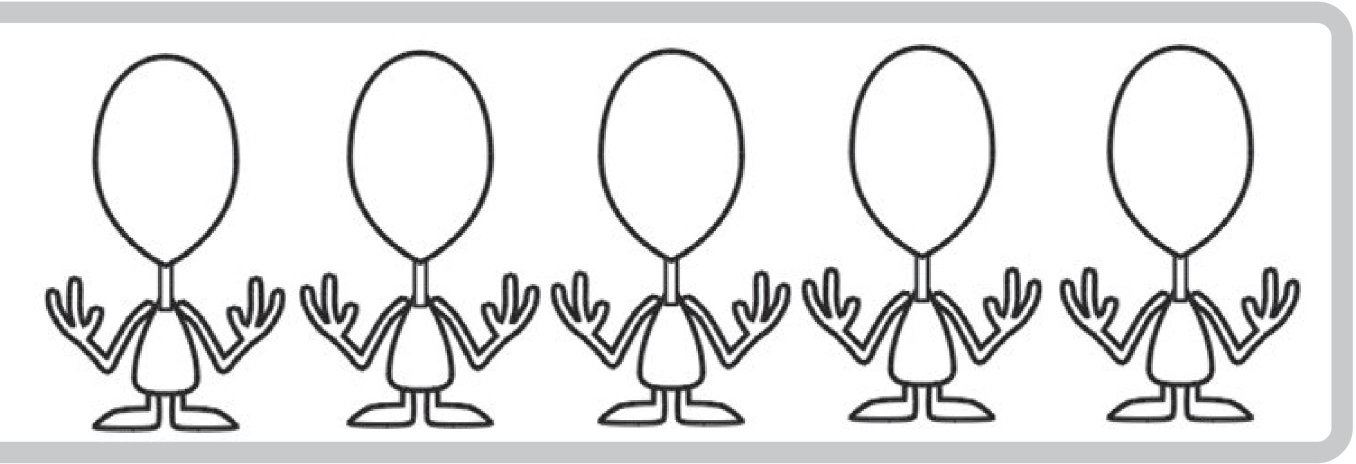
Derek said: It was Charles; It wasn't Alan

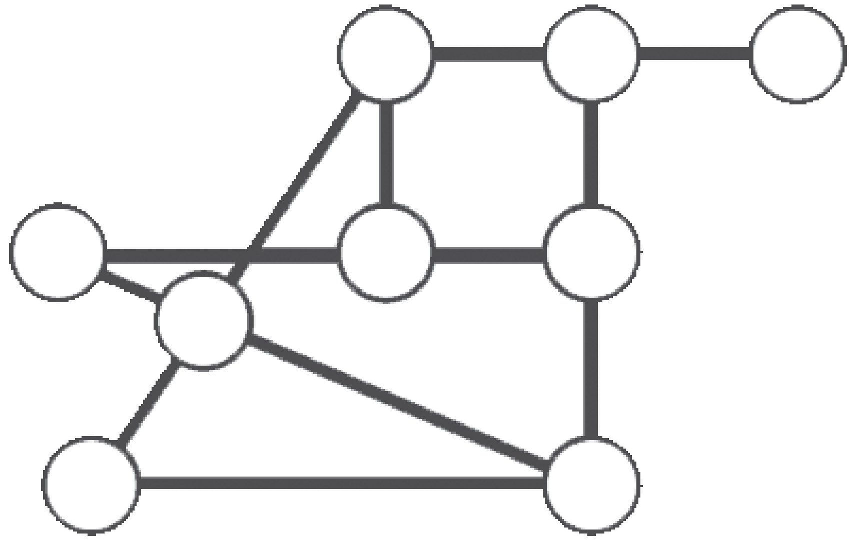
Charles said: It was Brian; It wasn't Eric

Alan said: It was Eric; It wasn't Brian

Eric said: It was Derek; It was Alan

Police know that each of them told the





truth in one of the statements and lied in the other. From this information can you tell who committed the crime?

Ans: Remember that each person told exactly one truth and exactly one lie. So Derek was the culprit. How can you reason this out?

Looking at Brian's statement if it was Charles, then Brian was lying in his first statement, which makes the second statement true. Which would mean that it was both Charles and Alan. So it can't be Charles.

Which means Derek was lying in his first statement, which makes the second statement true. Therefore it can't be Alan.

So Eric's second statement must be false, meaning his first statement was true, therefore it was Derek.

2. *You have the misfortune to own an unreliable clock. This one gains exactly 15 minutes every hour. It is now showing 3.00am and you know that is was correct at midnight, when you set it. If the clock stopped four hours ago, what is the correct time now?*

Ans: It is 6:24 AM. To figure out this, the first thing is to find out how many clock-minutes pass for each real hour.

Since the clock is gaining 15 minutes every hour, for every real hour that has passed, the clock will show 75 minutes.

Since the clock shows 3.00 AM, we know that 180 clock minutes have passed. This equals 144 real minutes (180 / 75 x 60), so the clock shows 2.24 AM.

The clock stopped 240 minutes ago (4 hours), so the time must now be 6.24 AM.

From: brainbashers.com

Making Sudokus Count

R. Ramanujam,
The Institute of Mathematical Sciences, Chennai

I hope you are all as fond of Sudokus as I am. I am not a "puzzle fiend" like some of my friends are but Sudokus charm me more than most puzzles. Perhaps one reason for this is that solving them is only half the fun. I enjoy simply *looking* at the Sudoku before getting into it; there are usually a great many patterns to be noted, symmetries to be observed, and predictions to be made about which regions would be easy to fill. I try to designate a few cells as the `villains', the ones that will cause maximum anguish. All this before starting, and if any of the predictions come out right, the resulting joy is far greater than solving the puzzle.

			2				6	3
3					5	4		1
		1			3	9	8	
							9	
			5	3	8			
	3							
	2	6	3			5		
5		3	7					8
4	7				1			

What messages can a partially filled Sudoku give, apart from offering some obvious candidates of numbers for a few cells? Instead of answering this question, let me suggest that you look at a few Sudoku puzzles yourself, and develop whatever ideas you get. In this article, I will try and show at least some interesting mathematical ways of thinking about Sudokus that can stimulate such observation.

What it is

For the unfortunate ones who don't know what Sudokus are, here is a quick introduction.

Take a look at Figure 1. We have a 9 by 9 square with some of the 81 cells filled, each with a positive integer in the range 1 to 9. The objective is to fill in every one of the 81 cells subject to three conditions: *the row constraint* (RC), *the column constraint* (CC), *the box constraint* (BC) and *the uniqueness guarantee* (UG).

Let us name the set {1,2,3,4,5,6,7,8,9} of the first nine positive integers *N*. The row constraint specifies that each of the 9 rows gets a permutation of *N*. (A permutation of a set is an arrangement of its elements in any order. With {A, B, C} we get six permutations: ABC, ACB, BAC, BCA, CAB, CBA. In general, if a set has *k* elements, we have *k!* permutations, where *k!* (read as k-factorial) is the notation for the product k x (k-1) x ... x 2 x 1. The leftmost position can be filled in *k* ways, the next one with any of the remaining (*k*-1), the next one with any of (*k*-2), and so on.)

Similarly, the column constraint forces a permutation of *N*. Note that the 81 cells of Sudoku are arranged in 9 squares, each 3 by 3. The first three rows give three boxes, the next three rows give three more boxes, and so on. Thus we have 9 boxes, and the box constraint forces each box to contain a permutation of *N* as well. The uniqueness guarantee says that there is only one way to fill in the remaining cells to give a solution.

So, if we fill any cell with a number from *N*, we must remember that no other cell in the same row, column or box as this cell is going to get the same number. The uniqueness guarantee seems to offer comfort; not only are we sure that we are not wasting time, there is in fact a solution, but also that we need not be confused by many different possibilities. Every cell is destined to match a unique number, we only need to make this match.

That's it, with this knowledge you can solve any Sudoku.

How it looks

While the newly excited ones are busy solving the Sudoku in Figure 1, the rest of us can discuss some generalities.

We have a 9 x 9 Sudoku with three constraints. Is the number 9 necessary? Does the set need to have exactly the first nine positive integers? Would changing any of these kill the joy of solving the puzzle? Surely, we can agree that the three constraints and the way they interconnect are the only essential ingredients.

A first generalization is to think of any *m* x *m* Sudoku, filling in cells with elements of any set *N* with exactly *m* elements. Thinking thus, RC and CC are natural but with BC we have a problem. Can we ensure *m* boxes? (Do we need to?) If not *m*, can we ensure some number of complete boxes (of the same size) at all?

A simple answer is to set *m* to be k^2 for some positive integer *k*. Then, we have RC, CC and BC. Let a sudoku have *rank k* if it is a $k^2 \times k^2$ figure, containing k^4 cells. It is also clear that the set *N* can have any symbols at all, with no need for ordering them in any way. We have so far been talking of rank-3 sudokus. Think of rank-4 and rank-5 sudokus, it's fun.

(Do we need names like 'rank' for talking of something that is supposed to be fun and entertainment? Why should we even talk of '*m* x *m*' sudokus? Well, using such language is *doing* or *making* mathematics, and I hope you find it as enjoyable as solving puzzles; I do.)

The mathematicians among you would worry about rank-0 and rank-1 sudokus. They are unique: rank-0 is the null sudoku that contains nothing, and the rank-1 sudoku is just a small box. What should it have? Any symbol you like.

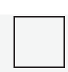


Fig. 2

What about rank-2 sudokus, the 4 by 4 grids? Why are they consigned to 'Sudokus for kids'? The answer is that they are very simple and easy to construct and solve, so they do not pose challenges. But then, just for that reason, they are also useful to get us thinking about sudokus, to prepare us for the harder questions on sudokus of higher rank.

Making Sudokus

Solving a rank-2 Sudoku may be easy, but how do you go about posing one? Oh, you say, that's trivial! Just take a filled in Sudoku, erase a few cells and give it.

Sure, but how many will you erase? If you erase too few, there is no fun; if you erase too many, are you sure you are respecting the uniqueness guarantee?

So, here is the question: for any rank-*n* sudoku, what is the largest number of cells that can be left blank, while ensuring a unique solution? Note that this is important for people posing sudokus, especially in different grades of difficulty.

This is not an easy question to answer, but with rank-2 sudokus, we can at least try experimentation. Try various 4 x 4 grids, remove cells, see if there are many ways to complete them. But then, how large is the collection of sudokus we need to work with? If the collection is vast, we may spend years experimenting, getting nowhere. Perhaps we can use computer programs to do this, but even computers give up beyond some size.

Thus the next question: how many distinct filled-in rank-*n* sudokus are there?

This, it turns out, is a really hard question, and hence attracts anyone who is mathematically minded. The intrigue is that for rank-3, the answer is a specific number, even though it is large. Are you surprised that until today we have only estimates of that number, and do not know it actually? This, with very clever mathematicians thinking about it, and many computer programs helping them. Is that not amazing?

The rank-2 case

4 x 4 sudokus are nice, since the two questions we have posed can be answered satisfactorily.

Let us take the latter question first. How many filled in 4 x 4 sudokus are there? A simple way to approach the problem is to start row by row and simply count. I am going to follow the convention of proceeding from top to bottom and left to right. So if I speak of the cell (2,3), then I mean the cell in the second row from top and third column from the left.

Let us start with an empty 4 by 4 grid. We can approach it in may ways, but let me choose to look at it as composed of four boxes. Let Box I have the cells (1,1), (1,2), (2,1) and (2,2); Box II is adjacent to it, and Box III is below it, leaving Box IV to be diagonally opposite.

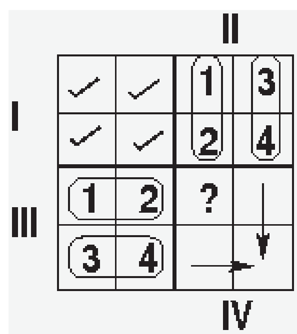


Fig. 3

Even with an empty grid at hand, we can make a very useful observation, and let us do it in style.

Proposition: If Boxes I, II and III are filled, there is at most one way of filling Box IV.

Proof: Consider the cell (3,3). The third row and third column by now together have 4 numbers, a_1, a_2, b_1, b_2, not necessarily distinct, but a_1 cannot be equal to a_2, just as b_1 cannot equal b_2. Thus among them, we have at least two distinct numbers. If all four are distinct, there is no way of filling (3,3) and we have no solution. If three are distinct we have a unique solution to (3,3).

Now suppose we have only two numbers among them. This means that the third (partial) row is exactly the same as third (partial) column. Let us say these are 1 and 2. But now note that the fourth (partial) row is exactly the same as the fourth (partial) column having the numbers 3 and 4 (see Figure 3 for an illustration). But then the only place in Box IV left for the numbers 3 and 4 would be the cell (3,3), and it cannot hold both numbers. Thus this case is not possible.

End of Proof

Can you re-work the argument and see that the proposition is actually more general: filling any three boxes fixes the fourth?

When we start with filling Box I, we are unfettered. So let us fill it in as we like. Why not 1,2,3,4? There are 4! = 24 ways of filling in this box. We will keep that in mind, but proceed with that choice.

What about Box II? Note that RC poses a constraint on cells (1,3) and (1,4): between them, they must contain the numbers 3 and 4, in any order. Clearly (2,3) and (2,4) must get 1 and 2 in some order. Further we see that cells (3,1) and (4.1) in Box III must contain the numbers 2 and 4 in some order and the cells (3,2), (4,2) get 1 and 3 in some order. These 4 pairs can be filled in 16 ways.

Now we can backtrack a bit and observe that this argument does not at all depend on filling in Box I in any particular way. For *any way* of filling it, we have 16 ways (in the manner argued above) for II and III.

Thus we have 24 ways for Box I and 16 ways for the other two, making 24 x 16 = 384 possible rank-2 sudokus.

But now recall the proof of the Proposition above. We can never have a column in Box II with the same entries in the corresponding row in Box III. Thus, of the 16 ways of fillings Boxes II and III, four ways lead to contradictions. Therefore there are only 24 x 12 = 288 possible rank-2 sudokus.

Another way

We now have a nice '*theorem*': the number of 4 by 4 sudokus is 288. That is not a large number, but for human beings, filling in that many figures is tedious, may even be daunting. Mathematicians are remarkably lazy in this regard, and always look for ways to order or group such collections further into subgroups, so that it is easy to 'picture' the collection.

What I mean is this: is there some pattern by which we can classify these 288 grids, without even having all of them on hand? The answer is yes, by way of what are called *transformations*.

Suppose you have a filled in grid. Now let us relabel 1 as A, 2 as B, 3 as C and 4 as D. The new grid is still a solution, though over a different set of symbols. But then we could equally have relabelled 1 as 2, 2 as 3, 3 as 4 and 4 as 1. We are applying the permutation 1234 —> 2341. Once again, the new grid is a solution, and is one of the 288. Thus we have:

If we have a filled in grid and apply a permutation on the 4 digits, we get another filled in grid.

Can we think of other transformations that take solutions to solutions? After some thought, we see that there are exactly four transformations, let us call them T1, T2, T3, T4.

T1. Permute the digits.

T2. Swap two rows or two columns common to a box.

T3. Swap two rows or two columns of boxes.

T4. Rotate or flip the whole grid.

Now let us try to build all the 288 grids. We can start with Box I. By T1, we might as well assume that it is filled as in Figure 4a. Now Row I of Box II can be either 34 or 43. By T2, we can assume it to be 34. Column 1 of Box III can be 2 above 4 or 4 above 2. Again by T2, we can assume 2 to be above. We then have the grid as in Figure 4b.

1	2		
3	4		

Fig. 4a

1	2	3	4
3	4		
2			
4			

Fig. 4b

1	2	3	4
3	4		
2		4	
4			

Fig. 4c

This places 4 uniquely in cell (3,3), giving us Figure 4c.

Consider (4,4): it can have either 1,2 or 3. But if it is 3, we can apply T1 and swap 2 and 3, getting Figure 4d.

Now by T4, we can flip on the top-left - bottom-right axis, getting Figure 4e.

1	3	2	4
2	4		
3		4	
4			2

Fig. 4d

1	2	3	4
3	4		
2		4	
4			2

Fig. 4e

Thus we can have either 1 or 2 in (4,4). Each of these choices lead to a unique completion, and we get the two grids in

1	2	3	4
3	4	1	2
2	1	4	3
4	3	2	1

Fig. 5a

1	2	3	4
3	4	2	1
2	1	4	3
4	3	1	2

Fig. 5b

Figures 5a and 5c.

Thus we see that there are only two really unique solutions for rank-2 sudokus, meaning that you cannot turn one of these into the other by simple operations that do not change the underlying structure of the grid. Every other grid can be obtained from one of these two by permuting the digits, swapping rows or columns common to a box, rotating or flipping the whole grid.

Ways of completion

We now get back to the question that started our discussion. for any rank-2 sudoku, what is the largest number of cells that can be left blank, while ensuring a unique solution? Alternatively, what is the smallest number of cells that need to be filled, to ensure a unique solution?

Transformations already give us a way of thinking about this.

Proposition: We need to have three or more cells filled in rank-2 sudokus to ensure a unique solution.

Proof: Suppose we had only two cells filled with numbers a and b, and we get a solution. Now consider the permutation of digits that leaves a and b unchanged but swaps the remaining two numbers. This gives another different solution, violating the uniqueness guarantee. So the assumption was wrong, and we need at least three filled in cells.

End of proof

Of course, the converse need not be true. That is, having three filled in cells is no guarantee of a unique solution. To see this, consider the incomplete sudoku in the figure; try to solve it. What do you find?

1			
		2	
	3		

Can you come up with a rank-2 sudoku with only three filled-in cells and with a uniqueness guarantee?

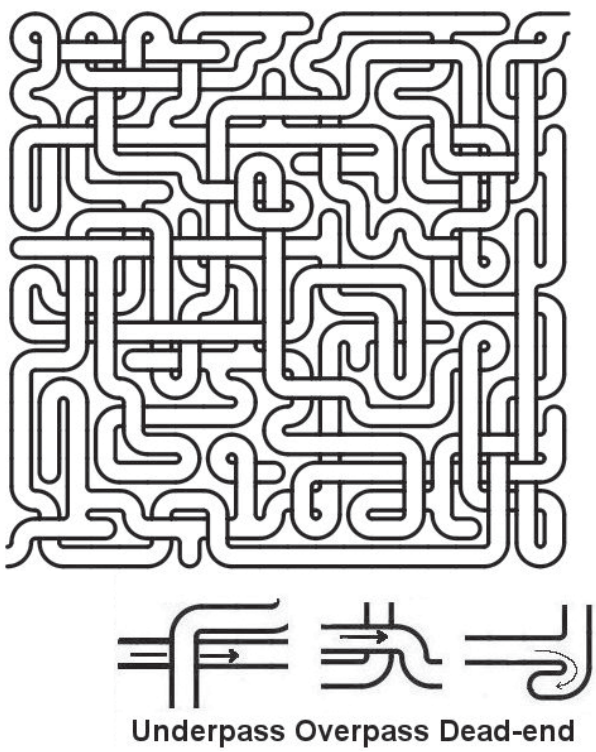
Last word

I hope this foray into the world of sudoku mathematics convinces you that there is a rich world there that awaits exploration.

For instance, why should we limit ourselves to square sudokus? Why not *rectangular* ones? Why not three-dimensional *cube* sudokus? And so on.

And of course, rank-3 sudokus are the most fascinating. Rank-2 are too easy and Rank-4 too hard. Perhaps you will discover some propositions about them; if you do, be sure to write to JM about it!

Show the way!



Estimate this

Kamal Lodaya,
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Question: If all the humans in the world were crammed together, how much area would we occupy?

Answer: There are 600 crore of us humans. How many can we cram into a square metre (that is, a square which is 1 metre by 1 metre, or about 3 feet by 3 feet)? It is difficult to say, but certainly three of us can be comfortably placed inside such a square. Putting ten of us inside a square of that size would be very difficult. So let us {estimate} that the number of people which can be crammed into a square metre is six.

This means that 600 crore of us can fit into 100 crore square metres. That sounds like a lot, let us see how big it is.

A hundred crores is 10^9, 10 multiplied by itself 9 times. Now 1 square kilometre is 1 kilometre x 1 kilometre = 10^3 metres x 10^3 metres = 10^6 square metres. So 100 crore square metres is $10^9/10^6 = 10^3$, or a thousand square kilometres.

A thousand square kilometres sounds like a lot, let us see how big a square that would need.

If we take a square which has each side 30 kilometres long, its area would be 30 x 30 = 900 square kilometres. So a square which is a little over 30 kilometres long should be enough.

A big city like Chennai or Chandigarh is more than 30 kilometres long and 30 kilometres wide. A mega-city like Delhi or Mumbai is even bigger. So the answer is: all the humans in the world could be fitted into one city.

You might be thinking that the question is ridiculous. We cannot just cram people, they need some space to live in... So here is a question to think about.

Question: Supposing we gave every family a house to live in. Now how much area do we require to house every family in the world?

Answer: For the answer, we first need to estimate the size of an average family. In India it is close to 4, but in the western world, it is closer to 3. So let us say an average family has 3 people but we will compensate by giving each family not only a house but a yard around the house. There are 600 crore people in the world so there are 200 crore = $2x10^9$ families.

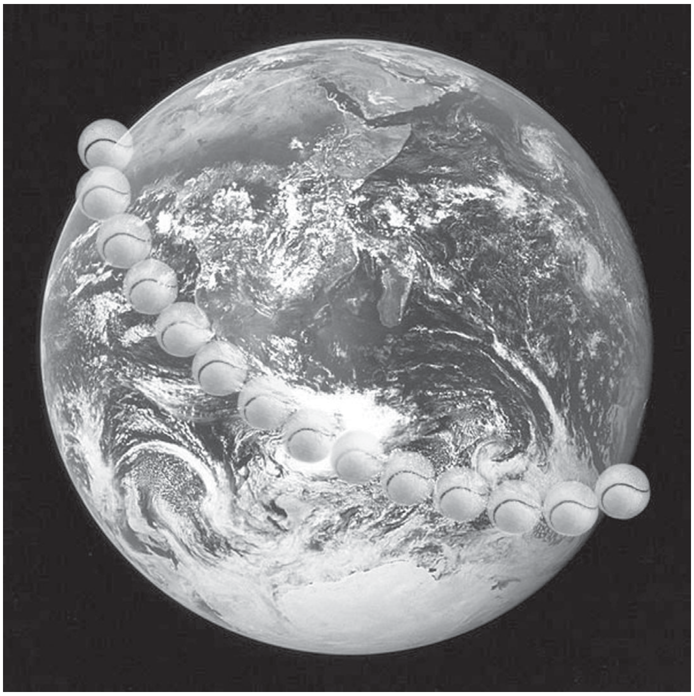
How much area should a family get? A house would be around 10 metres long, a football field would be around 100 metres long. We will take 30 metres, so that there is a generous yard all around the house. So the area of a house is 30x30, or about 1000 square metres. All the families together will need $2x10^9x1000 = 2x10^{12}$ square metres.

A square kilometre is $1000x1000 = 10^6$ square metres, so that is $2x10^6$ square kilometres. That sounds a lot but it is the area of a triangle which is 2000 kilometres high and has a base of 2000 kilometres (since the area of a triangle = half its base times its height).

The southern half of India (the Deccan region) has the shape of a triangle of about this size. So all the world's families can be comfortably housed in south India.

Question: Here is a more frivolous question for you to think about: How may tennis balls would it take to encircle the Earth?

Answer: We need to estimate the size of a tennis ball and the size of the Earth.



Well, from what I remember, a tennis ball is around 7 centimetres in diameter, but let us take it to be 5 cm. For the Earth we could look up a geography book or find it on the internet, but the whole idea of this article is to estimate numbers, not look them up.

But we will need some geographical data. Let us assume you know, as I do, that Chennai is on latitude 13 degrees north and Delhi is around latitude 33 degrees north or 20 degrees further north. I also know that the Tamil Nadu Express takes 33 hours to cover the distance from Chennai to Delhi, and given the average speed of trains in Indian railways, that would mean that the distance is around 2000 kilometres.

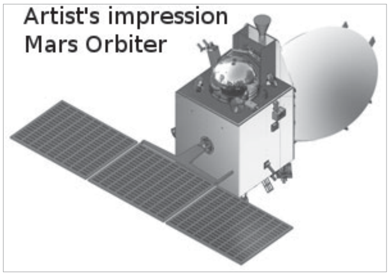
So 20 degrees of latitude is 2000 kilometres, or 10 degrees of latitude would be 1000 kilometeres. This means that 360 degrees of latitude would be 36000 kilometres. That is the circumference of the Earth. In centimetres it is $36x10^3x10^5$ = $36x10^8$. Dividing by 5 gives us $7.2x10^8$. So around 72 crore tennis balls, put side by side, should be sufficient to encircle the Earth.

Here is a question for ardent tennis fans: How many people play tennis? How many tennis balls will there be in the whole world?

Based on
Guesstimation, a book by
Laurence Weinstein and John A. Adam

Question:
Which shadow belongs to Santa?

Ans:
D



Mangalyaan

India's Mars Orbiter Mission

The Mars Orbiter Mission (MOM) was launched by India on 5th November 2013 by the *Indian Space Research Organisation* (ISRO). Informally called *Mangalyaan*, meaning "Mars-Craft", it is designed to orbit Mars like the Moon orbits the Earth. From its vantage point literally over Mars, it should send back valuable data about the red planet.

The launch details

Mangalyaan was launched on the *Polar Satellite Launch Vehicle*, PSLV-XL C25. As its name suggests, it is used to launch satellites into orbit and also launched the Moon probe *Chandrayaan*.

The PSLV has four stages using solid and liquid propulsion systems alternately. The first stage is one of the largest solid-fuel rocket boosters in the world. Six strap-on motors, four of which are ignited on the ground, augment the first stage thrust while two more are burnt in the air. Each stage burns for several hundred seconds only. A large number of controls make sure that the rocket does not topple and faces the correct direction without rolling. This time, the PSLV carried the Mars Orbiter, which weighs 1350 kg.

The payload

The payload is the object that is launched by the PSLV, that is, the Mars Orbiter. The photo shows the Orbiter undergoing tests before being placed inside the PSLV.

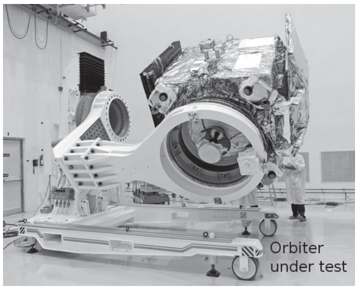
The next photo shows the Orbiter being attached to the fourth stage of the PSLV. You can see the heat shields surrounding the orbiter, ready to be closed, to protect the payload. Once closed, this will form the pointed or top end of the launch vehicle.

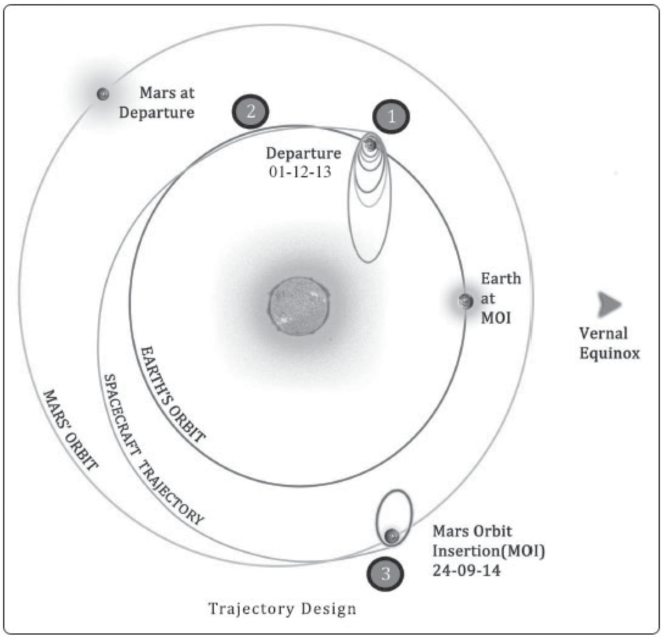
The next photo shows the PSLV, with its heat shield closed.

The orbits

You may have seen that a ball that you throw up always comes back and hits the ground. If you throw it with more velocity, it may reach farther (like a javelin or discus throw) but ultimately it reaches the ground. If a space craft should be launched so that it doesn't land back on the Earth, it should therefore have sufficient velocity. If it has a velocity of at least 11.2 km/s (about 40,300 km/hour), it can escape the Earth's gravitational field, so this velocity is called *escape velocity*.

Since the escape velocity is so high, it requires a great deal of energy (costly fuel) to impart such a high velocity to a rocket when it is launched. So the fascinating idea behind the launch of the Mars orbiter is that it is first launched similar to a satellite. That is, it is simply put into orbit around the Earth.

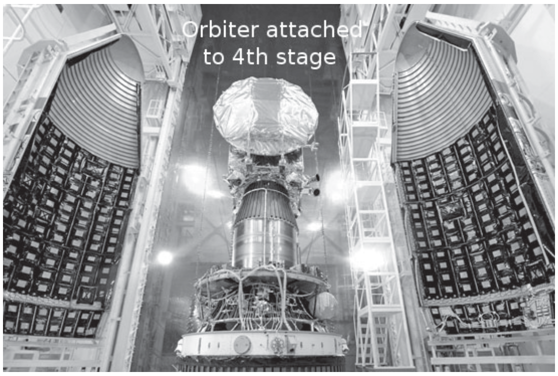


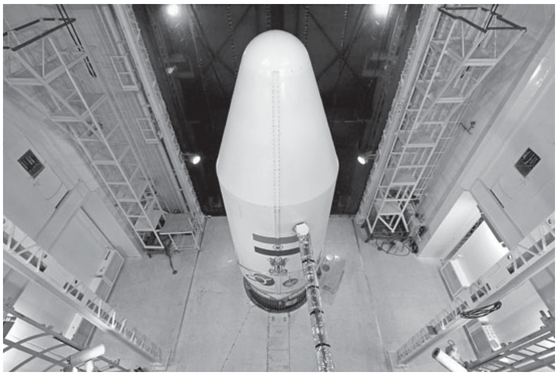


For this, a much smaller *orbital velocity* is needed.

Orbital velocity is the velocity needed to balance the two forces: gravity's pull on the satellite and the inertia of the satellite's motion, that is, its tendency to keep going. This is approximately 27,359 kph at an altitude of 242 kilometers.

Once the orbiter is launched as a satellite, this means it is put into elliptical orbit around the Earth. This is marked as stage 1 in the figure. From such an orbit, it is slowly given additional velocity (by burning its fuel in phases) so that it goes in increasingly larger orbits around the Earth. Finally, it is given a push that sends it out of Earth's orbit and into an orbit around the Sun. This is marked as stage 2 in the figure.

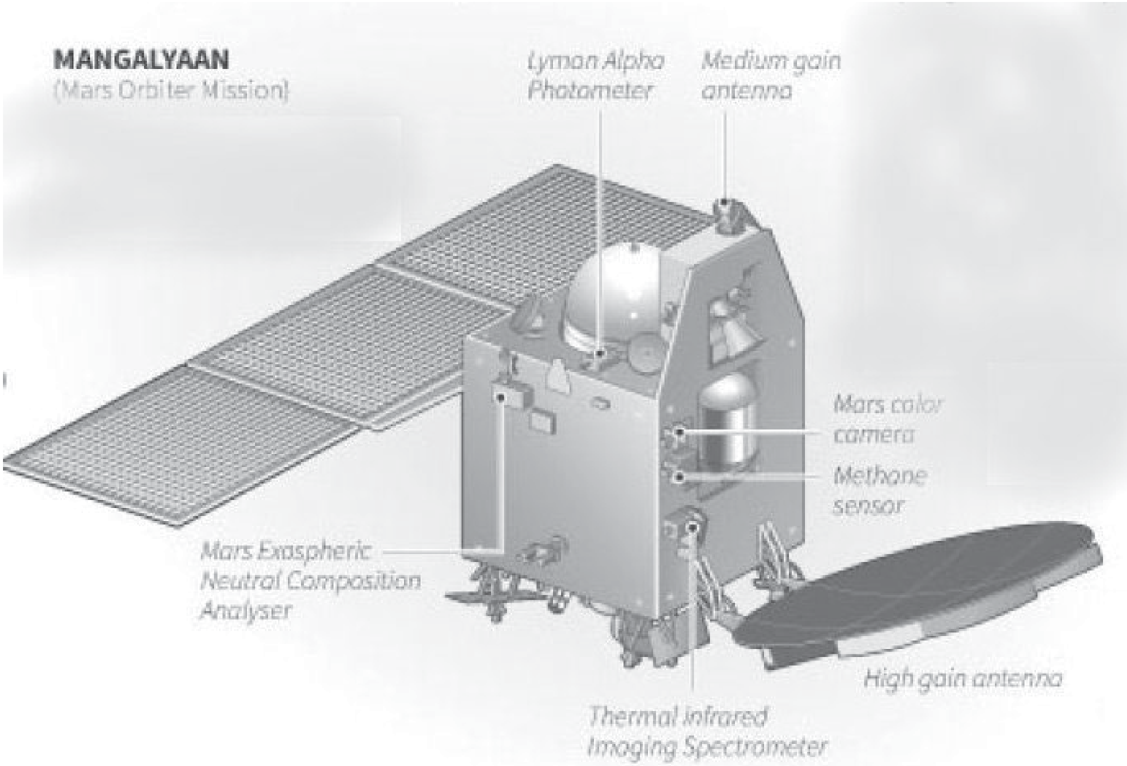




Now, Earth, Mars, and the orbiter are all three circling the Sun. The time of launch is calculated so that, at the point when Mangalyaan's orbit crosses that of Mars, Mars is also at that point! This happens after Mangalyaan goes about half an orbit around the Sun, about a year from now. Now that Mangalyaan was shifted successfully from its Earth orbit to its Sun orbit on Dec 1, it will simply keep moving in this orbit until Sep 2014, a journey of nearly eight hundred million km!

This trajectory becomes possible when the relative position of Earth, Mars and Sun form an angle of approximately 44 degree. Such an arrangement recur periodically at intervals of about 780 days or about 2 years.

Once it reaches Mars, it will be moved into an orbit around it. This is marked as stage 3 in the figure.



The Objectives

This is the first time India has launched a probe that has left Earth and its gravitational field, and will circle another planet. The launch itself is therefore an important objective since the complex manouvres required are already challenging. Once the probe reaches Mars, it is carrying a whole lot of scientific instruments that will probe the planet.

The Mars Orbiter Mission carries five scientific payloads to observe the Martian surface, its atmosphere and exosphere extending up to 80,000 km. It will measure quantities that will help us understand the evolution of that planet, not just geologically (its rocks and minerals) but also look for materials that may point to the existence of life forms.

The payloads consist of a camera, two spectrometers, a radiometer and a photometer. Together, they have a weight of about 15 kg.

The **Mars Colour Camera** (MCC) will be used for optical imaging. Its **Thermal Infrared Imaging Spectrometer** (TIS) will map the surface composition so that we can find out the minerals that are on this planet. The **Methane Sensor for Mars** (MSM) will detect the presence of Methane gas. The **Mars Exospheric Neutral Composition Analyser** (MENCA) will study the composition of Martian upper atmosphere. There is an advanced instrument called the **Lyman Alpha Photometer** (LAP) that is sensitive to the presence of hydrogen and will check for water on the planet.

The mission will add to the understanding of Mars that we have from other Mars probes, including the ones that have landed on its surface and are probing it.

—Compiled from

Information made available by ISRO.

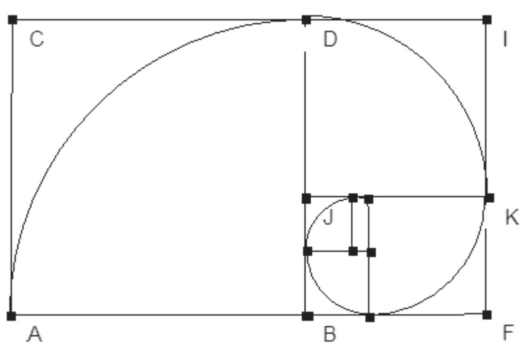
Response to article on Golden Ratio by M.V.N. Murthy in the Sep-Oct 2013 issue of JM

Meghna K.K.,
The Institute of Mathematical Sciences, Chennai

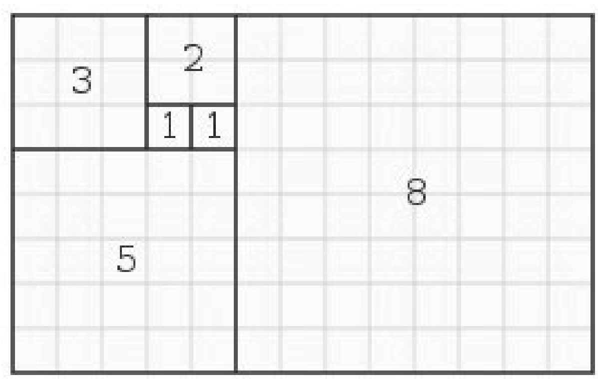
You have mentioned in your article that the golden ratio is seen often in Nature. In particular, the golden spiral is most beautiful. It can be constructed as follows. Look at the figure (from http://www.yorku.ca/lbianchi/nats1800/lecture10a.html).

Here ACIF and BJKF are *golden rectangles*. Using a compass, with centre at B, draw the arc AD; then, with centre at J, draw the arc DK, etc. The resulting curve is a *golden* or *logarithmic spiral*.

If you have difficulty constructing the golden



rectangles, another possible construction using only squares of different sizes (marked in the figure) is shown below.



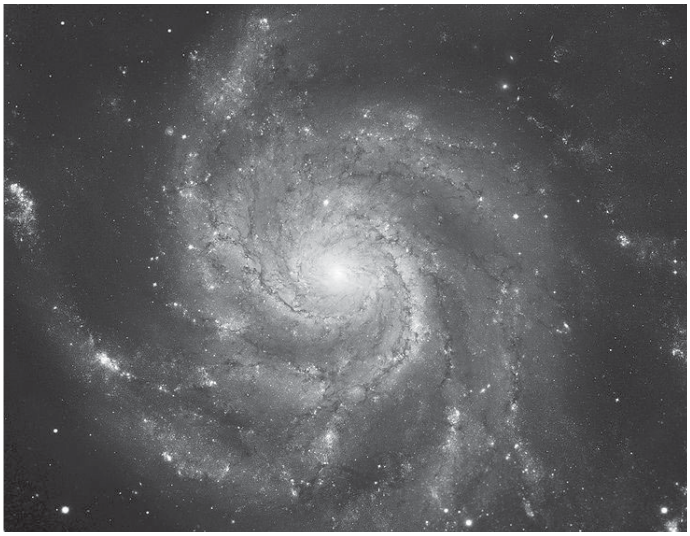
Golden spirals are seen in many places. Arms of spiral galaxies spread out in this shape.

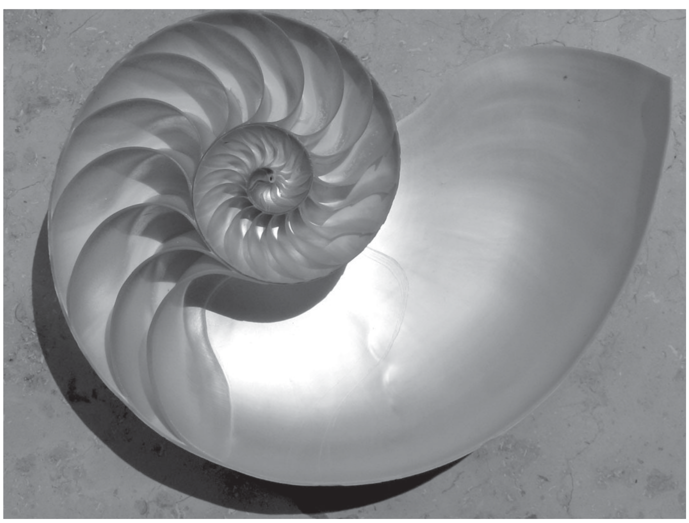
Also, many mollusc shells exhibit this shape. See the picture of the *nautilus mollusc's* shell. It has been cut in half to show the chambers clearly arranged in a golden (or logarithmic) spiral. Such a pattern is not just by chance: it allows the animal to grow without changing shape.

Many leaves of plants are also arranged in spiral shapes. The picture shows the criss-crossing spirals of the plant *Aloe polyphylla*.

Golden spirals are so elegant that they are found in paintings and in architecture. One of the most famous examples is the double spiral staircase in the *Vatican Museums* in the Vatican City near Rome. It was designed by **Giuseppe Momo** in 1932.

Note from Editors: Thank you for your information, which is most useful to our readers. Now that they know how to make a golden spiral, maybe they would like to make their own art-work!





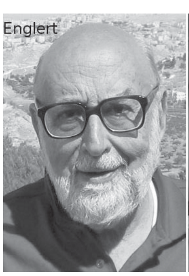
Nobel Prizes

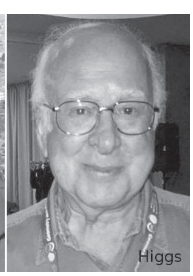
D. Indumathi,
The Institute of Mathematical Sciences, Chennai

Physics

As is usual, the Nobel prizes in science were announced in November. This time, the prize for physics goes to **François Englert**, Belgium, and **Peter W. Higgs**, UK, “for the theoretical discovery of a mechanism that contributes to our understanding of the origin of mass of subatomic particles, and which recently was confirmed through the discovery of the predicted fundamental particle, by the ATLAS and CMS experiments at CERN’s Large Hadron Collider”.

Some of you regular JM readers may remember a long article (actually a series) in the *Jul-Aug 2012* issue of the magazine on the Higgs boson. It is the particle, interactions with which give all fundamental particles their mass. Well, it was in the news last year because it was discovered in the CERN’s Large Hadron Collider experiment. It is again in the news not even a year later because the discoverers of this particle and this mechanism for mass have now been awarded the Nobel prize for this work which they did in 1964. Prof Englert and his colleague Prof Robert Braut (who is now deceased) wrote about their solution to this problem and Prof Higgs independently worked on it. Of course as with all science, many other scientists contributed to the understanding of this problem.





The Science

For more details about the science, do find the old JM issue again! In brief, we now believe that all matter is made up of fundemental particles such as electrons. However, particles such as protons and neutrons are not fundamental, or elementary, because they are made up of other fundamental particles called quarks. Also, other particles similar in nature to the electrons exist, for example, the muons, and they are collectively called charged leptons. Each of the charged leptons are associated with a neutral partner called neutrino.

All quarks and leptons interact with each other through four basic fundamental forces. Two of these are the well-known *gravitational* and *electromagnetic forces*. The *strong force* holds the quarks together inside the protons and neutrons, while the *weak force* is responsible for radio-activity.

All these interactions were coded into a mathematical theory which looked very elegant. However, for a long time, there was a problem: the elegance of the theory would break down if the particles had mass. It was in this context that these scientists wrote down a mechanism whereby the particles acquired mass through interactions with the Higgs field, but the elegance and symmetry of the theory was retained.

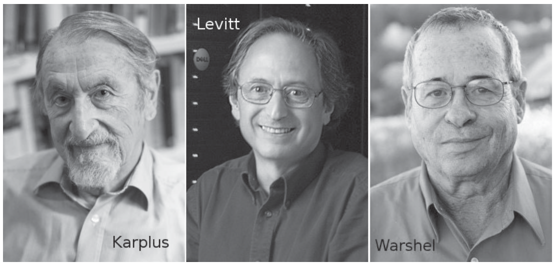
While the work is rather technical, the analogy used in the last year's issue can be repeated here.

A very popular analogy to the particles moving through the Higgs field is that of a pop star (or famous actor) moving through a crowd of fans. If you or I go through the crowds, they will simply let us pass through, but once they see the actor, they will surround him and won't let him move easily! You can say that the interaction with the crowd (the Higgs field) has given a large mass to the actor, but none to you or me!

Another way of thinking about it is to imagine a particle as a ship on a vast ocean. The friction between the ship and water causes it to slow down; this is like its mass while the ocean is the Higgs field. Waves in the ocean can be thought of as the Higgs particle. Whatever be the analogy, it remains an exotic answer.

You can always think of a particle as being far away from the influence of any forces. But even then it has a mass. In fact, a particle is characterised or recognised by its mass, otherwise we won't be able to tell electrons and muons apart. This means that the particle is always under the influence of the Higgs field and can never get away from it!

If this puzzle you, don't worry: it puzzles, and will continue to puzzle a large number of students in physics when they are taught this fact! But the final proof of a theory in Physics is the discovery of the prediction. And this has been recognised through awarding the Nobel prize to the scientists who came up with this idea.



Chemistry

The Nobel prize in Chemistry has been awarded jointly to **Martin Karplus, Michael Levitt** and **Arieh Warshel** of the USA "for the development of multiscale models for complex chemical systems".

The Science

This means that the prize has been given for work done in computer modelling of chemical processes. The main difficulty in understanding chemical processes of large and complex biological systems such as photosynthesis in green leaves is the sheer number of molecules involved in the process. What these scientists did in the 1970s was to separate the problem into two parts.

Only small portions of the molecules actually participated at any givewn time in an interaction. Large portions of the complex molecules did not participate directly in the interaction. They were modelled in a very simple way using classical Newton's laws. The molecules that were actually involved cannot be treated classically, since atoms require quantum mechanics to collectly understand their behaviour. Such quantum calculations require enormous computing power and initially could be carried out only for small molecules.

Karplus, Levitt and Warshel managed to study the system so that the interacting molecules were described quantum mechanically and the remaining bystanders were treated classically.

For instance, in simulations of how a drug couples to its target protein in the body, the computer performs quantum theoretical calculations on those atoms in the target protein that interact with the drug. The rest of the large protein is simulated using less demanding classical physics. Such models are now the basis of study for most chemists.

Physiology or Medicine

The Nobel Prize in Physiology or Medicine 2013 was awarded jointly to **James E. Rothman, Randy W. Schekman** and **Thomas C. Sudhof** of the USA (Sudhof was born in Germany) "for their discoveries of machinery regulating vesicle traffic, a major transport system in our cells".

These three scientists have solved the mystery of how the cell organizes its transport system. For instance, insulin is manufactured and released into the blood. Signalling molecules called neurotransmitters are sent from one nerve cell to another. These molecules are transported around the cell in small packages called vesicles. The three Nobel Laureates have discovered the molecular principles that govern how this cargo is delivered to the right place at the right time in the cell.

Schekman discovered a set of genes that were required for vesicle traffic. Rothman unravelled protein machinery that allows vesicles to fuse with their targets to permit transfer of cargo. Thomas Sudhof revealed how signals instruct vesicles to release their cargo with precision.

Through their combined discoveries, the scientists have revealed the exquisitely precise control system for the transport and delivery of cellular cargo. Disturbances in this system can contribute to conditions such as neurological diseases, diabetes, and immunological disorders. Without this wonderfully precise organization, the cell would lapse into chaos. Hence vesicle transport gives insight into disease processes.

Economics

The Royal Swedish Academy of Sciences has decided to award The Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel for 2013 to **Eugene F. Fama, Lars Peter Hansen**, and

Robert J. Shiller of the USA "for their empirical analysis of asset prices".

There is no way to predict the price of stocks and bonds over the next few days or weeks. But it is quite possible to foresee the broad course of these prices over longer periods, such as the next three to five years. These findings, which might seem both surprising and contradictory, were made and analyzed by this year's Laureates.

These findings not only had a profound impact on subsequent research but also changed market practice. The emergence of so-called index funds in stock markets all over the world is a prominent example.

From the Nobel Prize archives: www.nobelprize.org

Do You Know?

1. The Voyager 1 and 2 spacecraft went past Jupiter, Saturn, Uranus and Neptune. Has no one ever though of visiting Pluto?

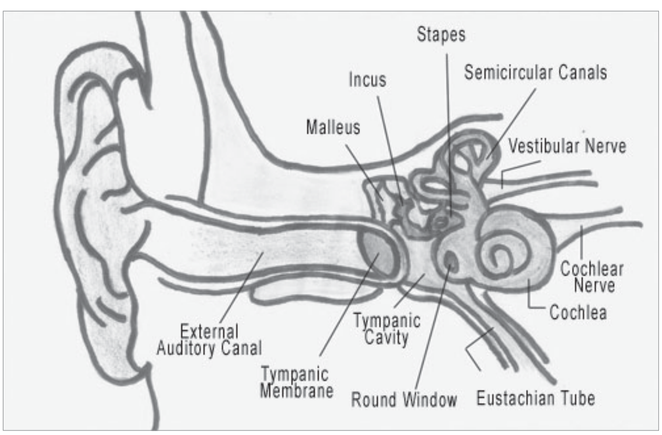
2. Which animals sweat?

3. How much damage can a rupee coin dropped from some height do?

4. What chemical leaks from batteries?

5. When ice falls as hail it is hard, whereas snow is soft. Why?

6. Was Einstein's brain different to mine?



Answers to last issue's Do You Know?

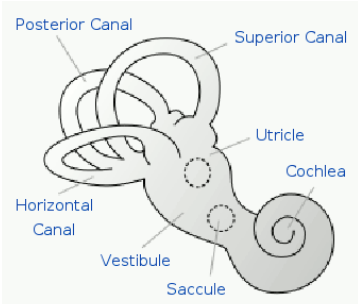
1. What is vertigo?

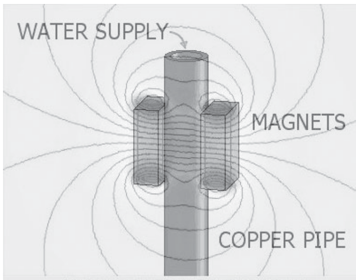
Ans: Vertigo is this sensation of dizziness or spinning and most people will have experienced it — if not at any other time when, as a small child, you spun round and round looking at the sky until you fell . But some people get it quite regularly and it's all to do with your inner ear. Inside your ear, you have three *semi-circular canals*, little sort of loops which are filled with fluid and they're all at 90 degrees to each other. That's how you know which way up your head is and which way it's moving because the fluid inside them moves, knocks into these little sensor hairs and that tells you how you're moving.

When you spin around, the fluid in them starts to spin as well, but after you stop, it keeps spinning for a while and that's what makes you feel dizzy after you have been spinning around. But lots of things can make you feel like you are moving even when you are not, which is what is happening in vertigo. There are some circumstances when it can be caused by little pieces of dirt that have found their way into the inner ear and they confuse the signals that are being sent to the brain. That type of vertigo tends to happen only when your head is in a certain angle so the dirt is hitting the little cells.

It can also be linked with migraines. In which case, the problem is probably actually not in your ear, but in the nerves or in the brain itself. But scientists still don't really understand migraines. They are a bit of a mystery to us.

Now, we may wonder why the body has evolved to make the decision that when you get motion sick-





Magnetic Water Treatment with a pair of neodymium magnets

ness or vertigo to throw up (vomit).

Well, vomiting is a sensible response if you have eaten something bad and it seems that dizziness can sometimes be an indicator of poison. It is very likely that this is how this trait evolved, that in some circumstances it was very useful to throw up because you had eaten something bad. And actually, if you throw up a few more times than you need to, that's better than not throwing up when you should.

2. Can magnets on pipes soften water?

Ans: This question comes up presumably because there is such a belief in many parts of the world. There are even commercial advertisements that refer to this belief. All this led some citizen science groups to investigate the claim that attaching magnets to pipes causes water to be soft, that scaling is avoided. The investigators concluded that there was no basis to the claim at all.

We can consider what the magnets could be doing. We have to think about what hard water is. It is mainly calcium and other minerals dissolved. There is a tiny amount of iron in there that could be affected by the magnets. But even this iron is it in a form which is actually magnetic. Most of it is in non-magnetic form, in one of the electronic configurations that are not magnetically active.

So why is the belief so prevalent? It is very likely a 'placebo' effect. After having spent the money to buy a gadget and put on the pipes, people expect to see a difference and hardly cut the pipes to see if scales have formed, so they think the water tastes 'good'.

3. Can we achieve artificial photosynthesis?

Ans: Yes, artificial photosynthesis does indeed exist. Photosynthesis is essentially the means by which energy from the Sun is captured and used to split water molecules to generate fuel for the plant to use in growth. What scientists are trying to do is to use the principles from natural photosynthesis to harvest the Sun's energy and convert it into fuel. The main challenge being met in the field is in the splitting of water.

If we split water we produce hydrogen, and hydrogen is a much cleaner fuel than the fuels we are currently using, and this fuel can be used, for example, using fuel cells to power cars.

The challenges scientists are facing at the moment are coming not just from the light harvesting side where we have the same challenges as in *solar cells*, but also from the *catalyst* side because the catalysts have to be very efficient and very robust. The catalysts are essential because they speed up the reaction, and in general increase the efficiency of the device. At the moment, platinum catalysts fulfil these criteria. However, they are very expensive, so scientists are working on cost effective catalysts such as copper based and nickel based ones.

4. Why do migratory birds fly in a V-formation?

Ans: The linear flight formations of migratory birds are called *echelons*. The V and the J formations are typical and are the most readily recognized flock echelons, but other variations also occur. Studies of several species have shown that a true Vshaped echelon is, in fact, less common than a J formation is.

There are two well-supported and complementary explanations for why birds fly in formation. One is to conserve energy by taking advantage of the 'upwash vortex fields' created by the wings of the birds in front. The other is to facilitate orientation and communication among the birds. These explanations are not mutually exclusive, and both have been backed by a variety of studies. The relative importance of each undoubtedly shifts as various factors, such as the season of the year or the purpose of individual flights, change. During local feeding flights, for example, energy conservation is probably much less important than careful orientation and collision avoidance are.

During long-distance migration, orientation and communication remain necessary, but there is also much to be gained for each bird in the flock by optimizing its position to conserve energy.

Fluid dynamics and energy wave configuration calculations have been used to test predictions of where birds should position themselves in relation to others to conserve the most energy as they travel through the air. Analyses of flock formations using photography have measured bird positions and found them to almost always be located such that they gain some energetic advantage. The animals are not very often in the expected optimal location, however, indicating that other factors also influence position in the formation.

Knowledge of birds' visual axes, "blind spots" and field of vision have allowed researchers to pinpoint the best locations for birds within a flock to maintain optimal visual positioning. Actual positions of the animals are usually similar to these predictions but are, again, not always optimal. Studies have categorized the positions of birds and found that some individuals take positions that are most closely predicted to satisfy the energy conservation hypothesis; others are in better visual contact positions; and still others are not apparently responding to either benefit or are in a position that should gain some advantage from both benefits.

The leaders of formations change from time to time, but the causes, frequency and characteristics of these changes have not yet been determined. Sustained observation from the ground of flocks covering great distances in the air is very difficult. There are plenty of intuitive predictions about leader choice that quickly come to mind relative to the age, experience, sex, condition and social status of the leaders, but researchers have not figured out how to overcome the prohibitive logistic issues to test them. Some scientists have trained birds to fly in formation with small aircraft; perhaps their experiences will yield opportunities to test these ideas.

5. Would music sound different on Mars?

Ans: In fact, another similar question often comes up too. Is it true that on Mars, no one can hear you scream? First up, we can do some calculations. In general, the speed of sound is proportional to the square root of the substance's stiffness divided by its density. Since Mars's atmosphere has a lower density than here on Earth, you'd expect the speed of sound to be faster than here on Earth. But if you reduce the pressure of a gas, the stiffness also reduces. So, the speed of sound should stay about the same on Mars as it is on Earth. But there's an-

The atmosphere's lower density is not suited to human speech and hearing systems which have evolved for life on Earth. Instead, radio waves, a form of light travels fine through low densities and so, can be used as a method of communication up there which is how exploratory rovers on Mars like Curiosity communicate, not with each other but with us on Earth using radio wave messages traveling at the speed of light and taking about 15 minutes to be received here on Earth.

other factor to consider. Mars is further away from the Sun. How does this affect the speed of sound?

The difference is temperature. If you reduce the temperature of the atmosphere, the speed of sound does get slower. In fact, the speed of sound on Mars is about 2/3 of the speed of sound on Earth.

So, say two humans were to land on Mars, given the slightly lower speed of sound there, could they still speak to each other?

The speed of sound on Mars is around 240 meters a second, a bit lower than the 340 meters a second on Earth. By itself, that would not make sound communication harder. However, the atmospheric density of Mars is less than 1% of Earth, almost a vacuum by our standards. This means that sound attenuation is much greater and so, speech would not carry very far. Human mouths and ears would not be able to couple sound efficiently into or out of the thin Martian atmosphere, so humans would be effectively deaf.

6. What is the lifetime of a comet?

Ans: Comets are actually large clumps of ice and rock that were left over when the planets were formed. We can think of them as huge dirty snowballs orbiting the Sun. Being snowballs, this means that they can melt and they also actually do melt.

Every time a comet passes close to the Sun, a part of it *sublimates*, meaning that the snow and ice turn directly into vapour and this is the vapour that we can see as one of the tails of the comet. So, since part of the comet sublimates every time it passes the Sun, it cannot live forever.

Recently the **ISON comet** came very close to the Sun, reached perihelion on 28th November 2013 (closest point of approach to the Sun) and completely disintegrated within the next few days. On the other hand, we have, for example, **Haley's comet**, which is quite well-known since it passes the Sun once every 75 years or so, and this comet will be completely sublimated and disappear after only 10,000 years or about 100 rotations around the Sun.

This is a typical lifetime for a comet. But still, this does actually not mean that there will come a day when all the comets are gone and that is because there are huge hidden supplies of comets waiting beyond the orbit of Neptune. That is the Kuiper belt and the Oort cloud. These regions continuously replenish the inner Solar System with new comets.

Source: The Naked Scientist

Science News

Headlines

. Exploring the moon, dwarf planets and asteroids from Vesta to Ceres

. The long flights of dragonflies

. How about gold that grows on trees?

. The Koala males have a deep voice

. Hot never looked so cool: vanadium dioxide

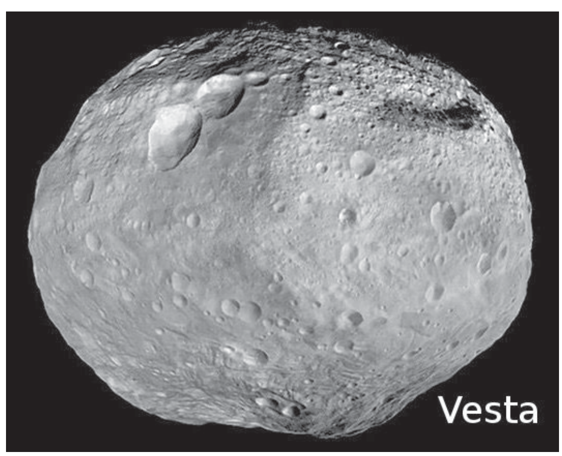
. Ultra-small movies, starring molecules

For more details, read on

. From Vesta towards Ceres

In September, the American space agency NASA launched the **Lunar Atmosphere and Dust Environment Explorer** (LADEE), a robotic mission to the moon (see inner cover for photo). It entered lunar orbit on October 6, 2013 and is successfully communicating with Earth using laser pulses. It has recently been joined in its orbit around the moon by the Chinese moon mission Chang'e 3, also an unmanned mission.

In the meanwhile, NASA's "**Dawn**" mission, launched in 2007, was aimed at **Vesta**, one of the largest asteroids in the solar system and the brightest asteroid visible from Earth. After studying Vesta for a year, Dawn is now headed towards the dwarf planet **Ceres.** Ceres is the largest asteroid and the only dwarf planet in the inner Solar System.



Dawn reached the bright asteroid Vesta (discovered by the German doctor of medicine and amateur astronomer **Heinrich Olbers** in 1807) in July 2011. The pictures from Dawn suggest that Vesta may also have been a planet in the making, with many similarities to the rocks and material found on the Moon. On a full moon night one can usually see "rays" emanating from the crater **Tycho** (see picture) on the Moon; craters on Vesta also have rays like these.

After orbiting Vesta for a year, in July 2012, Dawn's rockets were fired to move it to a new orbit which will reach the dwarf planet, Ceres (discovered by the Italian priest, mathematician and astronomer Giuseppe Piazzi in 1801), in February 2015.

Like Earth, Ceres has denser material at the core and lighter minerals near the surface. Astronomers believe that water ice may be buried under Ceres' crust because its density is less than that of the Earth's crust, and because the dust-covered surface bears evidence of water-bearing minerals. Ceres could even boast frost-covered polar caps.

Astronomers estimate that if Ceres were composed of 25 percent water, it may have more water than all the fresh water on Earth. Ceres' water, unlike Earth's, is expected to be in the form of water ice located in its mantle.

. The long flights of dragonflies

Bird migration is well known and familiar to most of us, but birds are not the only creatures that depart from cool climates in search of warmer ones in autumn, and the reverse in the spring. Monarch Butterflies are also well-known long-distance migrants, but so are many other insects, including other species of butterflies, moths, locusts and dragonflies.

Migration by dragonflies has been recorded sporadically for several centuries. European records of this date back to 1494. Since 1998, there has been extensive research on this. Most swarms are sighted between late July and mid-October, with a peak in September. Most of the large flights occur along lakeshores and coastlines. Massive swarm migrations go with northerly winds following the passage of cold fronts.

The **Common Green Darner** (Anax junius) is the predominant species in the majority of these flights. About 16 to 18 species are regular migrants,

with some making annual seasonal flights while others are more sporadic. The Common Green Darner, weighing about one gram, travels more than 600 km over a two-month migration. There are interesting similarities between bird and dragonfly migration behaviour. Like migrating birds, dragonflies stop over at feeding spots occasionally to refuel along the way.

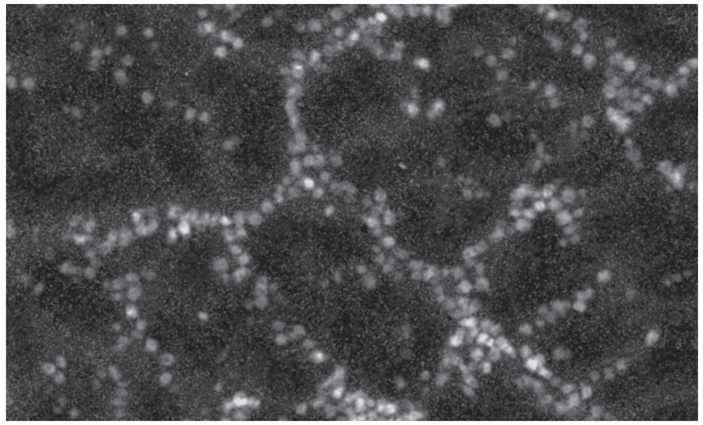
In fact, during migration Common Green Darners often spend as much or more time feeding as they do making long flights. On average in North America they migrate in a southward direction every three days, covering roughly 50-70 km in 5-7 days. Common Green Darners migrate exclusively during the day, regardless of wind direction, but only after two nights of successively lower temperatures. Like many migrating songbirds and hawks, dragonflies appear to avoid flights over extensive open water, even if it means going miles out of their way.

Dragonflies begin their adult lives in autumn with very little fat, undeveloped ovaries and functional but incompletely-developed flight muscles. They quickly increase muscle mass and fat stores — more so than local breeding dragonflies that don't migrate — and some species periodically lay eggs in ponds along their migratory route during their southward flight.

. How about gold that grows on trees?

A group of geochemists from Western Australia has announced finding tiny grains of the precious metal in the leaves of eucalyptus trees.

If you're picturing gold leaves glittering in the sun, forget it. The specks of leaf-bound gold are only one-fifth the width of a human hair and just about as long. In fact, to find these *nano-nuggets* the team had to use a very powerful set of X-ray eyes called the *synchrotron*.



The leaves are not worth mining. Still, the greenery can lead to real riches How? The leaves can point to where mining teams might want to drill in search of a potentially rich seam of gold. Or of some other mineral — because sources of any rare mineral spotted in tree leaves may highlight ore hiding deep below the surface.

Geologists have actually known for years about the value of using plant or animal material to explore for buried minerals. The process is called *biogeochemical prospecting*.

What is interesting is how trees move and concentrate such a metal, they bring it up from such a depth as a 10-storey building.

But plants aren't the only ones to do this. Termites need moist material to hold their big mounds together. In desert regions those insects have been known to bore 40 meters (131 feet) down, for example in Botswana. And occasionally they drag gold back up along with the mud they were seeking.

Non-digging animals can help too. Kangaroos, for example, eat plants that may have taken up gold.

Bringing gold to light is just accidental for the plants, insects and kangaroos. It can prove a huge stroke of luck for geologists, however. After all, why dig and drill to look for gold if the local flora and fauna can do the dirty work for you?

. Hot never looked so cool!

The hotter it gets, the more it glows. This rule applies to stovetops and light bulbs alike. But it does not hold true for everything. Scientists report finding a rule-breaker — one that appears to cool down even as its temperature climbs. A material like this could be used to build objects that can fool infrared cameras, the kind that see heat, rather than visible light. It may also help scientists design heating and cooling systems that will use less energy.

Not all materials respond to changing temperatures in the same way. As their temperatures rise or fall, some substances change the way they respond to light or electricity. That's true for *vanadium dioxide*. At temperatures below 70 degrees Celsius, this material acts like an insulator. That means electricity can't easily pass through it.

Above 70C, things change. The compound suddenly becomes a conductor. Electricity now readily passes through it. Scientists don't know exactly why vanadium dioxide does this. But its behaviour gave physicists at Harvard University an idea: perhaps that switch in the compound's electrical properties would also change how much it glows. As the material's temperature climbed from 60 to 74C, it gave off increasing amounts of radiation. That means it glowed brighter and brighter. Then something strange happened. Even as the compound's temperature continued to rise, its glow began to diminish.

This means the material hides its true temperature, by appearing cooler as it continues to warm. Scientists don't yet know how the material rearranges its structure to pull off this trick.

. The Koala males have a deep voice

Scientists have just turned up a second set of vocal cords in koalas. These bonus vocal cords allows males to hit tones 20 times lower than would be expected from an animal its size.

The size of an animal's voice box and its flapping vocal cords dictate the range of pitches that an animal can make. For a typical 8-kilogram male koala, its voice should fall within the high-pitch range of any animal choir. Yet the male's mating songs include very low bellows — tones usually created only by elephant-sized mammals. Although these tones may make a female koala swoon, to the human ear, the low-pitched sounds resemble only a string of belches and snorts.

A team of scientists wanted to probe how the serenading males reach those deep bass tones. They dissected the voice boxes of 10 male koalas. They found that koalas possess a unique, second set of vocal flaps. The bonus ones reside outside of the voice box. Their placement allows them to belt out those low, low tones. These extra vocal cords make the koala quite unusual, both in terms of its anatomy and its acoustics — those sounds it makes, according to a recent issue of Current Biology.

Compiled from several sources

activity page

Boggle'd

Boggle is a word game designed by Allan Turoff and trademarked by Parker Brothers and Hasbro. Here we play a smaller version of the traditional game.

How to play

Search for words that can be constructed from the letters of sequentially adjacent squares, where "adjacent" squares are those horizontally, vertically or diagonally neighboring. Words must be at least three letters long, may include singular and plural (or other derived forms) separately, but may not use the same letter square more than once per word.

An example "REAP" is already done for you.

The original game has a time limit of 3 minutes and uses 4 X 4 squares. Here, your time limit is the next JM issue! Do write in your word list to the JM address given in the magazine and we'll print the ones with the most number of words. Don't forget to write in your name and address.

Sudoku

Rules

. Use the numbers from 1 to 6.

. Every row must have all the numbers from 1 to 6.

. Every column must have all the numbers from 1 to 6

. Every sub-rectangle must have all the numbers from 1 to 6

. The central shaded square (in the medium puzzle) must have the numbers 1 to 4

(A sub-rectangle is the 2 x 3 rectangle; the 6 x 6 square is broken up into 6 such sub-rectangles.)

Use the numbers already filled in as hints to complete the grid. Each Sudoku puzzle has a unique solution.

Send in your answers to us at the JM address given elsewhere in the magazine. Don't forget to write in your full name and address.

EASY

	4				5
		1		4	
				1	
	2	5			
			4		
	6			3	

MEDIUM

		6	3		2
		1			
					4
2				6	
4	1				5

A	P	R
H	E	P
S	S	N

A	P	R
H	E	P
S	S	N

Crossword

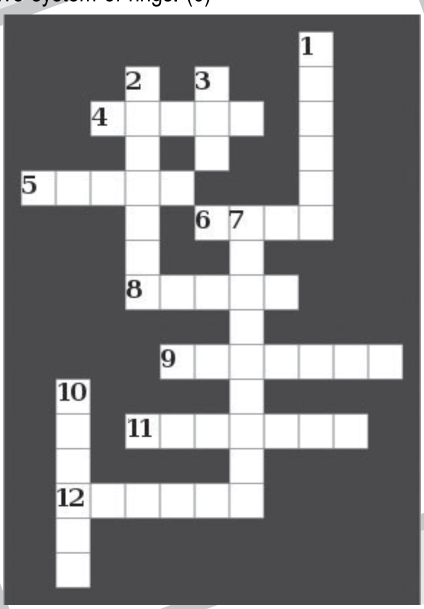
Here is a puzzle for you on the Solar System, from the Jefferson Lab, http://education.jlab.org

Across

4. Although not the closest to the sun, this planet is the hottest because of a thick atmosphere of carbon dioxide. (5)
5. This object is no longer considered to be a planet. (5)
6. Its two satellites are named Phobos and Deimos (Fear and Panic). (4)
8. You were born on this planet, hopefully. (5)
9. The closest planet to the sun, it orbits the sun once every 88 days. (7)
11. This planet is more massive than all of the others combined. (7)
12. This planet's axis is so tilted that it orbits the sun on its side. (6)

Down

1. Made mainly from ices and dust, these objects can form tails
millions of kilometers long when they pass near the sun. (6)
2. Named for the Roman god of the sea. (7)
3. This object is at the center of the Solar System. (3)
7. Chunks of rock, most of which are found between the orbits of Mars and Jupiter. (9)
10. This planet possesses the Solar System's most impressive system of rings. (6)



MINARAL

BLLOUGE

GRANULA

NOPOLGY

LIICENN

Jumble

Unscramble the letters to get five ordinary English words. Fill them in the adjoining boxes. Make a word with the circled letters and guess the answer to the puzzle below.

Out of this Earth—at least its influence.

Ans: _ _ _ _ _ _ _ _ _ _ .

Send in your answers to JM at the address given in the magazine. Don't forget to write in your name and address.

Solutions to last issue's Activities

Boggle'd

Possible words are are, back, backing, bag, ban, bank, bar, bare, barn, beak, bean, bear, brag, brain, braking, bran, break, breaking, cab, can, car, care, era, gab, gain, garb, grab, grain, ink, kin, king, nab, rack, rag, rain, ran, rang, rank.

Alas. No-one sent in solutions to Boggle'd. Try out the one in this issue: it's a great way to improve your visual skills.

CrossWord

Across

1. LARYNX 2. CIRCULATION 3. EPIDERMIS 5. TENDON 6. PULSE

Down

1. LIGAMENT 4. PUPIL

Jumble

1. GOURD 2. XYLEM 3. SEPAL 4. ONION

Essential for burning?

Ans: Oxygen

Sudoku

EASY

1	6	5	4	2	3
4	3	2	5	6	1
2	5	6	1	3	4
3	4	1	2	5	6
6	2	4	3	1	5
5	1	3	6	4	2

MEDIUM

3	4	1	5	6	2
5	6	2	4	1	3
6	1	4	2	3	5
2	5	3	1	4	6
4	2	6	3	5	1
1	3	5	6	2	4

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The Camel's foot tree

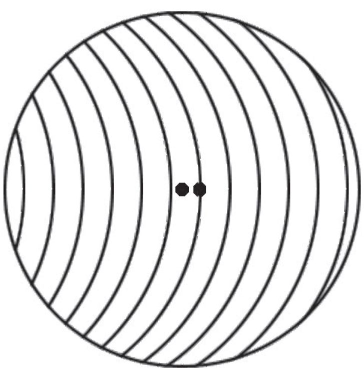
Its formal name is **Bauhinia purpurea**. It is native to South East Asia and South China. Apart from the name Camel's foot tree, it is also called Butterfly tree or Hawaiian orchid. In Tamil Nadu it is called Mandaarai.

It is a deciduous tree, not very tall, growing to about 5 m or so. It has long leaves, upto 20 cm long. They are very broad, rounded and have two lobes at both the base and the apex, giving each leaf the appearance of a double-lobed kidney.

It has very pink, small flowers (see the cover photo) with five petals, which are not only very pretty but also fragrant. A local variety, it will be in full bloom in December, so go out and look for it now! Soon long pods (about 30 cm long) of the fruit will appear, each containing 12 to 16 seeds.

Its well-shaped leaves are very convenient for making "*dhonnai's*" or eco-friendly bowls for serving food in.

The tree is considered to have antibacterial and anti-inflammatory qualities and is hence used in all forms of traditional medicine—Ayurveda, Siddha and Unani. All parts of the tree: the bark, the flowers, stem and seeds are used in medicine.



Question: Which dot is really in the centre of the circle?

Ans:

The left one