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The subtlety of rainbows

John Hardwick

Subtle physics is needed to explain many of nature's mysterious atmospheric optical phenomena, including rainbows, ice-crystal haloes and the much rarer fog-bows, dew-bows and glories.

In his poem of 1820 entitled Lamia, John Keats complained that cold philosophy had destroyed the mystery of nature, and that Newton, through his work on optics, had "unweave[d the] rainbow". Such a sentiment would find little sympathy with most scientists – or with many artists today for that matter. Indeed, an understanding of natural phenomena can only enhance our appreciation of nature and art.

Although it has long been known that a rainbow is produced by the dispersion of white light through rain droplets via refraction, there is far more to this optical phenomenon than first meets the eye. More complex and subtle interactions between light and water droplets can also create the "fog-bow", the "dew-bow" and the "glory".

Rainbows explained

Despite being a familiar sight, rainbows are much harder to understand than one might think. The ingredients are, of course, sunlight and rain droplets. Although the Sun's rays that reach the Earth are essentially parallel, the light impinges on a spherical droplet at a wide range of angles to the surface, where it undergoes refraction. When the light reaches the back of the droplet, two things can happen. The light can either refract and continue in a forward direction out of the drop, or it can be reflected internally, before passing back out through the front surface of the droplet via another refraction. It is this second process – in which light is refracted, reflected and refracted again – that creates the rainbow, which explains why rainbows only appear when one looks away from the Sun into a rain shower.

1 Bow beautiful

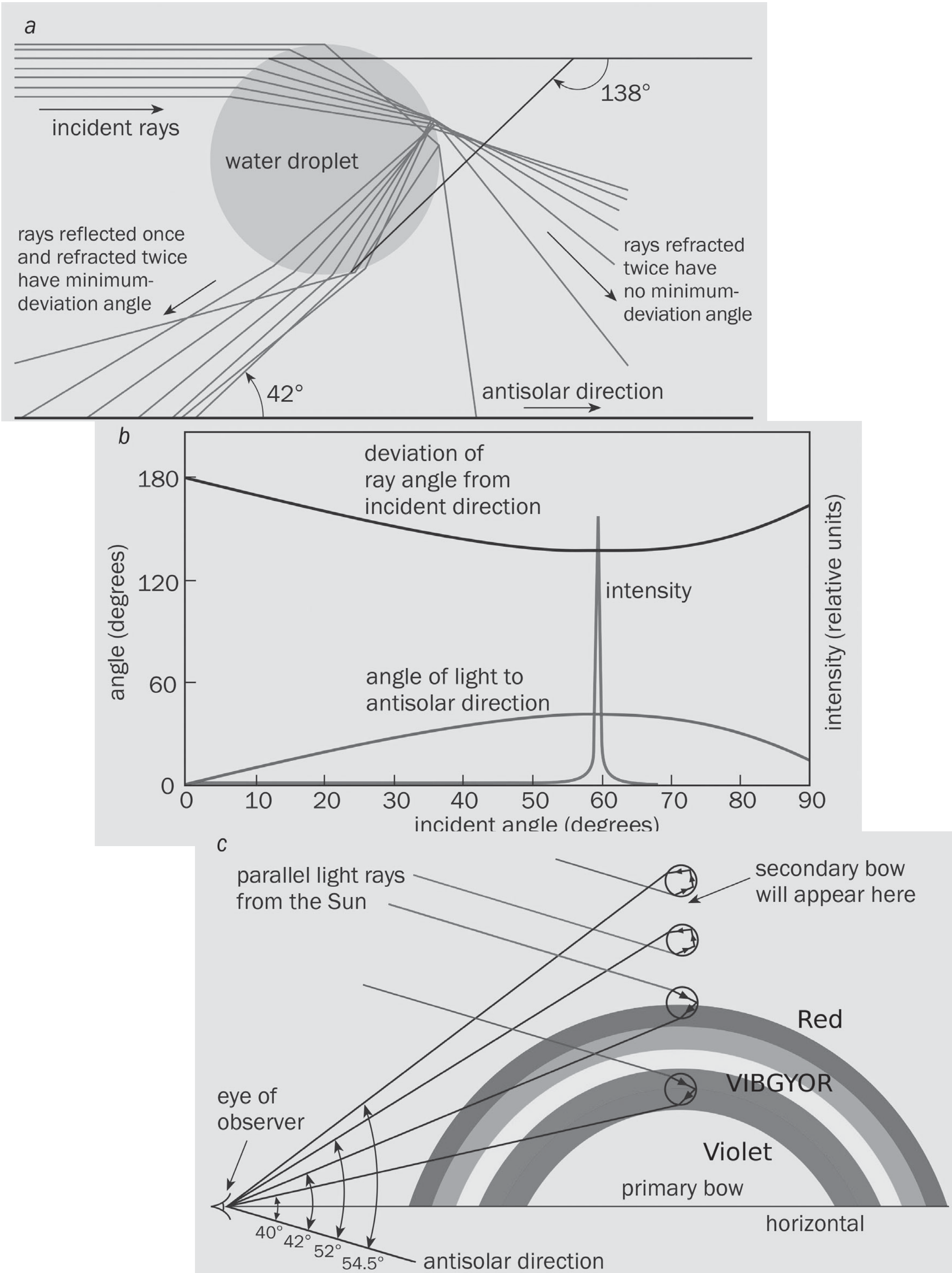
There are, however, innumerable raindrops at many different heights and positions above the horizon. As a result – and because of the many different angles at which the sunlight strikes the droplets' surfaces – we receive light rays at many different angles to the "antisolar direction", which is the direction looking away from the Sun towards the shadow of our head. So why does the bright, coloured arc of the rainbow only appear centred on this direction and at a specific and narrow range of angles to it?

Consider first what happens when the incident light strikes the surface of a droplet head on. Some of the light continues straight through the drop, while the rest reflects directly back. For the latter, the "angle of deviation" between the incident and reflected beams is 180°. But as the incident light strikes the droplet at a larger angle, the angle of deviation falls below 180°. When the incident light strikes at even larger angles, the deviation eventually reaches a minimum value, before rising again.

2 Rainbow optics

A parallel beam of sunlight strikes a spherical rain droplet. Despite being parallel, the light strikes the droplet at a wide range of different angles. The light undergoes refraction as it enters the droplet before undergoing reflection and further refraction. The "angle of deviation" between the incoming and outgoing rays passes through a minimum value for each wavelength, which is 138° for red light. The intensity of the deviated light (red line) reaches a maximum at this angle and is responsible for the creation of a "primary" rainbow. Different colours have different minimum-deviation angles because the refractive index of water depends on wavelength. The angle between light from the primary rainbow and the "antisolar direction" is 42° for the red bow and 40° for the violet bow. A separate, less intense, "secondary" bow can also be created from light that undergoes not one but two reflections from inside the droplet. The colours of this bow appear in reverse order to the primary bow.

At the minimum-deviation angle the rate of change of deviation angle with incident angle is zero. What this means is that light striking a droplet over a relatively wide range of incident angles emerges concentrated in a narrow – and


a
incident rays
water droplet
138°
rays reflected once
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have minimum-
deviation angle
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twice have
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42°
antisolar direction
b
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180
120
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0
angle (degrees)
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angle of light to
antisolar direction
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0 10 20 30 40 50 60 70 80 90
incident angle (degrees)
c
parallel light rays
from the Sun
secondary bow
will appear here
Red
VIBGYOR
Violet
eye of
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primary bow
horizontal
40° 42° 52° 54.5°
antisolar direction

almost parallel – direction. For example, light rays spanning a 13° interval around the incident angle for minimum deviation are focused down to an emerging beam with an angular width of just 1°. Light travelling in this direction has a relatively high intensity and forms part of the standard – or "primary" – rainbow with which we are all familiar.

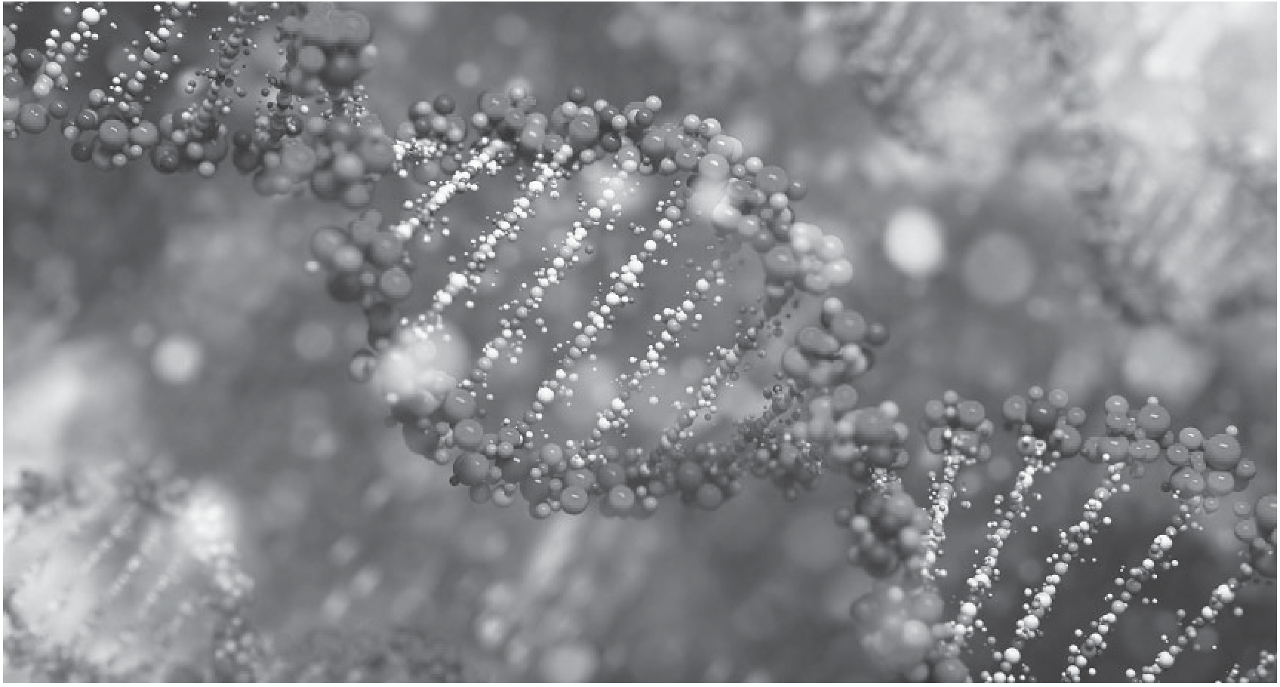
Different colours have slightly different minimum-deviation angles; it is about 140° for short-wavelength violet light and falls to 138° for red light. The violet component of a primary rainbow is therefore on the bow's inner side – about 40° to the antisolar direction – while the red component is on the outside at about 42° . Other colours fall in between. As the Sun rises, all that changes is that we see less and less of the rainbow's arc as the "antisolar point" – the centre of the circle of which the rainbow is a part – and the outer limbs of the bow gradually sink below the horizon. Interestingly, if the Sun is higher than 42° above the horizon, minimum deviation rays can only be received from drops located at angles below it, which is why rainbows are generally not visible when the Sun is high in the sky at the middle of the day.

Another interesting property of a primary rainbow is that the intensity of light coming from below it is higher than the background intensity from above it. This effect is visible in figure 1. The reason for this is that rain droplets cannot contribute to any light coming from angles above the rainbow because light cannot be bent round a droplet by less than the minimum angle of deviation. Some of the light scattered by the raindrops can, however, reach the observer from below the rainbow, which is therefore brighter than the area above it – but, of course, not nearly as bright as the rainbow itself.

Although a large proportion of light exits the drops after a single internal reflection to form the primary rainbow, some light can undergo two internal reflections. Such twice-reflected rays, which also have minimum-deviation angles and associated intensity maxima, form a "secondary" bow. This appears above the primary bow at an angle of about 52° to the antisolar direction. The secondary bow is fainter than the primary bow and its colours appear in the reverse order. A secondary bow is just visible in figure 1.

What about those light rays that pass out through the droplets in the forward direction after two refractions and no reflection? These have no minimum deviation, which means that this light does not reach a maximum intensity at any -particular angle. In other words, if we look towards the Sun through rain, we will see no bright rainbow but just an overall forward glare.

However, in principle, a "tertiary" bow can also be formed after the light has undergone three internal reflections in a droplet. This would occur when looking towards the Sun at an angle of about 40°, but it would be fainter than the secondary bow and obscured by forward glare. There have been some reported sightings of a tertiary bow (D E Pedgley reported seeing one in 1986) but no photographs exist, so far at least!



Silencing genes - to understand them

How scientists block cells' genetic messages — and why

Kathiann Kowalski

Scientists have identified all of the genes that lie within our DNA, depicted here. Now they're probing what all of those genes do — and they often use RNA interference.

The DNA in each of us hosts about 21,000 genes. Their blueprints are coded in the roughly 3 billion rungs of our DNA's ladder-like structure. The Human Genome Project finished decoding all of those genes in 2003. That task took hundreds of scientists more than 12 years.

Scientists are now working fast and furiously to learn what each identified gene does. Their answers will help science better understand how cells work. The knowledge also could help doctors better treat disease.

"One great way to learn what cells do normally with all their different genes is to turn off those genes one at a time," explains Craig Mello. He's a geneticist at the University of Massachusetts Medical School in Worcester.

David Root is a geneticist at the Broad Institute in Cambridge, Mass. To show how turning off genes can help, Root likens our complex genome — the complete encyclopedia of our genes — to the main electrical box in your house, full of fuses or circuit breakers. If none of the circuits feeding the box was labeled, he says, "You might turn each [circuit] off and see which of your lights go out or which of your appliances turn off."

Craig Mello and Andrew Fire discovered RNA interference through their studies with the millimeter-long nematode C. elegans. The tiny worm has only about 1,000 cells in its entire body.

As it happens, our cells can naturally turn off genes. The cells in many other species do too. They use a process called RNA interference, or RNAi. (Like DNA, RNA is a molecule found in all cells.) Mello and Andrew Fire, now at Stanford University School of Medicine in California, shared a 2006 Nobel Prize for discovering this process for silencing genes.

Scientists can trigger RNAi too. And by doing so, “We can trick the cell into shutting down any one gene — pretty much any gene in the whole genome — any time we want,” says Mello.

Turning off genes this way allows scientists to find out what they do when they’re on. Read on to see how RNAi works and what new work that uses it shows.

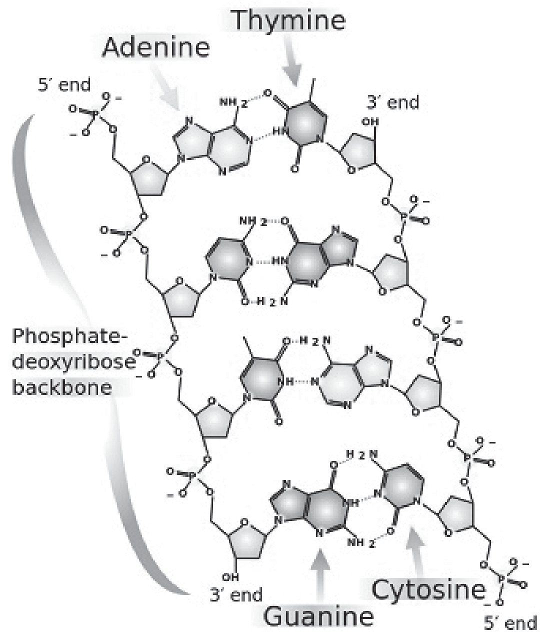
Our genetic alphabet

Cells have two kinds of genetic material: DNA and RNA. Our genes reside on DNA. Its long molecules resemble twisted ladders.

Each rung in DNA’s ladder-like structure is a pair of two chemicals — called nucleotides. Together they make up a base pair. The four nucleotides in DNA are known as A, T, C and G. They stand for adenine, thymine, cytosine and guanine. The nucleotide attached to each long side on the twisted ladder must pair with a particular one on the other side. All A’s, for instance, pair with T’s. C’s will only pair with G’s.

“The order of these four different units in the string is what defines the human genome sequence,” Root explains. That order provides the chemical code that defines what a gene will do. The Human Genome Project spelled out that code for all our genes, letter by letter.

The four bases (A, T, G and C) which form the "rungs" of the DNA "ladder" are also marked.



“DNA is a lot like the hardware in a computer. It’s something you’re born with,” says Mello. “Every time the cell reproduces,” he explains. “it reproduces a full set of these instructions that allow the cell to do its thing.”

Putting DNA’s instructions to work is one job of RNA.

“RNA is also a string of four different units, and it matches up one-to-one with DNA,” Root says. Three of those units are the A, C and G found in DNA. But in RNA, “instead of the T, you’ve got a U.” That U stands for uracil. Like T, it always — and only — binds to A.

While some types of RNA are double-stranded, most forms have a single strand of nucleotides. Different types of RNA do different jobs.

Messenger RNA, or mRNA, carries a gene's instructions to structures in a cell known as ribosomes (RY-boh-sohmz). This information tells other RNA molecules in those ribosomes to make some particular protein. Those proteins will carry out most of a cell's functions.

But not every cell needs to do every task. For example, nerve cells and skin cells have very different tasks. Nor must each cell work at the same time.

Instead, each cell expresses — or turns on — the genes that it needs for a particular job at some particular time. Different RNA molecules help control that process.

One way RNA does this is with proteins called Argonautes. These specialized proteins, named for a band of heroes in Greek mythology, bind to small RNA molecules. They help coordinate other proteins in events that result in the eventual silencing of a gene.

"Argonautes are very much like the search engines we use on our Web browser," says Mello. The small RNAs function like the query for a search. They resemble the few words that you might type into a search window to find detailed information about a topic. Argonautes work with bigger chunks of information to find matches for the search query. And, Mello notes, "Argonautes can do this very rapidly."

When the short piece of RNA bound to the Argonaute matches up with part of a specific messenger RNA, the Argonaute protein cuts the mRNA. The mRNA falls apart, and that destroys its message. Thus, the ribosome never gets the instruction to make a certain protein.

This process is RNA interference, or RNAi. It keeps cells from making proteins that aren't needed at that time. Cells also use RNAi "to clean up any RNA that shouldn't be there or that isn't perfect," explains Lisa Stanek. She's a neuroscientist at Genzyme Corp. in Cambridge, Mass.

The process happens naturally in animals, plants, fungi and even some bacteria. Says Mello: "We think RNA interference is at least a billion years old!"

Hijacking the process

Since the first news about its discovery in 1998, researchers have wanted to use RNAi to study cells. To do that, scientists learned how to "hijack it and reprogram it," says Christof Fellmann. He's a molecular biologist at Mirimus Inc., in Cold Spring Harbor, N.Y.

Scientists can trigger RNAi, for example, by introducing synthetic double-stranded RNA molecules. Their shape "resembles a

The structure of RNAi molecules, depicted here, usually resembles a twisted hairpin.

short hairpin," Fellmann explains.

A triggering molecule must contain a string of 21 or 22 nucleotides. Each of these will pair precisely with part of the target mRNA. Those short genetic sequences are like search queries. They find and link to the mRNA from a single gene — that gene's messengers. They seek it out from among all the materials inside the cell. That action cuts off the gene's instructions. In effect, the change turns off the gene and reprograms a cell.

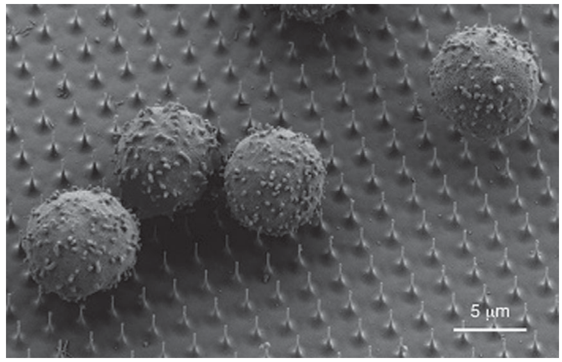
"Nature had millions of years of evolution to fine-tune these things," Fellmann notes. Making artificial triggers for RNAi, he believes, could help in both research and medicine.

Of course, triggers need a way into cells. One trick: Stuff them into a virus and then let the germ ferry the molecule into target cells.

"Viruses' jobs are to infect cells," explains Stanek at Genzyme. First, bioengineers take out all genes that might make someone sick. Then they tinker with the germ. "We engineer the virus to deliver our RNAi," she says.

Getting an RNAi trigger into a cell is only part of the task, though. "To figure out what a gene can do, you actually have to do that experiment over and over again, because the answer turns out to be different in different kinds of cells and conditions," explains Root at the Broad Institute.

"You don't necessarily learn about what a gene does in neurons by changing that gene in an immune cell," he notes. You can't tell, "even by looking at a neuron in isolation," he adds. And changing the



To turn off specific genes in certain immune system cells (shown in purple), researchers working with the Broad Institute found a way to "inject" RNAi triggers with pointy nanowires (shown in gray).

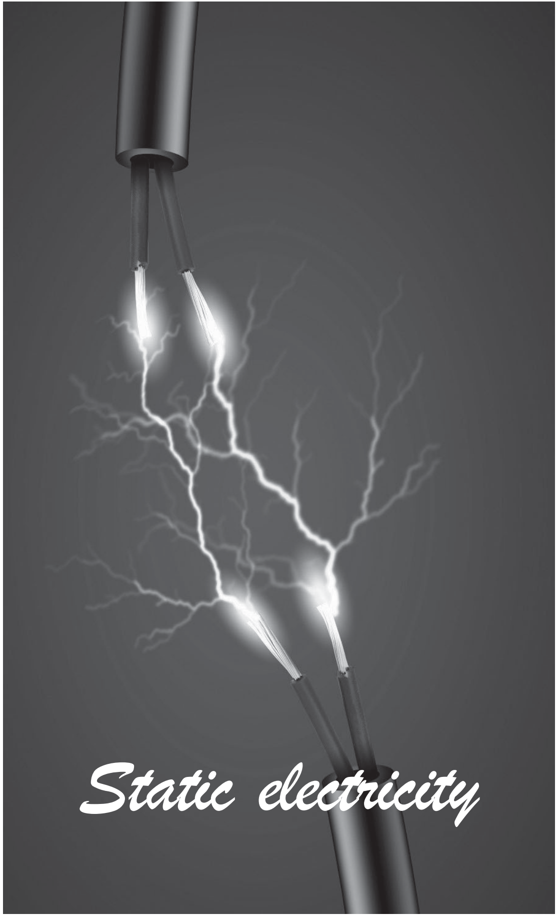
environment that surrounds a cell may change the way it behaves when a gene is silenced.

Fortunately, automated equipment lets researchers test many kinds of cells and triggers at once. Tests don't need much space, either.

"On your palm you can fit several hundred RNAi experiments," says Anastasia Eskova. She's a cell biologist at the Max Planck Institute for Developmental Biology in Tübingen, Germany.

RNAi helped show Eskova and her colleagues how some cells move. Other RNAi research aims to treat disease. For example, Root and other researchers are looking for better gene targets to treat cancer. All in all, RNAi is a powerful tool and may help science understand how life works at the most basic level. And with so much left to learn, today's young people may be the ones who ultimately make some of these important discoveries.

https://student.societyforscience.org/article/silencing-genes-%E2%80%94-understand-them?mode=topic&context=39



Protons, neutrons and electrons are very different from each other. They have their own properties, or characteristics. One of these properties is called an electrical charge. Protons have what we call a "positive" (+) charge. Electrons have a "negative" (-) charge. Neutrons have no charge, they are neutral.

The charge of one proton is equal in strength to the charge of one electron. When the number of protons in an atom equals the number of electrons, the atom itself has no overall charge, it is neutral.

Electrons Can Move

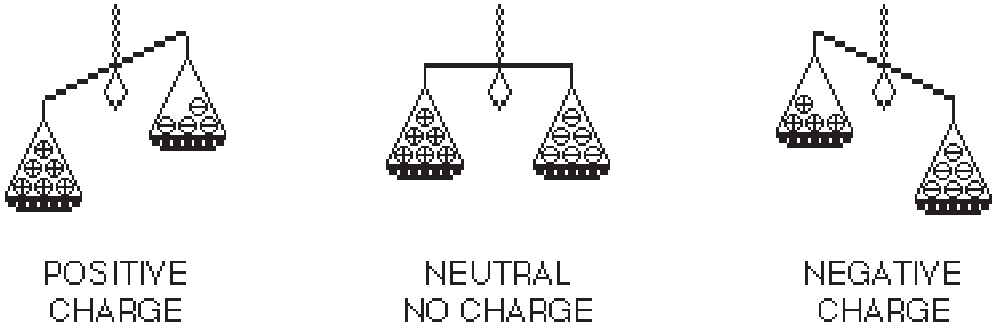
The protons and neutrons in the nucleus are held together very tightly. Normally the nucleus does not change. But some of the outer electrons are held very loosely. They can move from one atom to another.

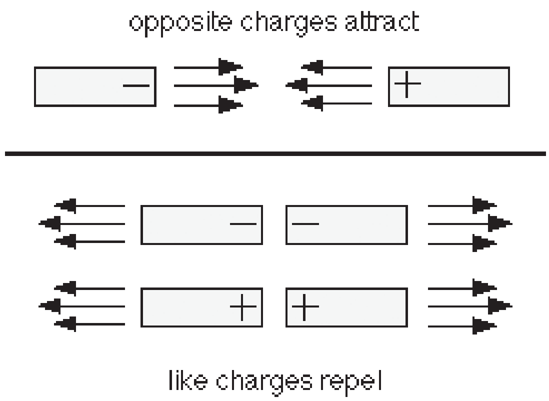
An atom that loses electrons has more positive charges (protons) than negative charges (electrons). It is positively charged. An atom that gains electrons has more negative than positive particles. It has a negative charge. A charged atom is called an "ion."

Electrical charges

Some materials hold their electrons very tightly. Electrons do not move through them very well. These things are called insulators. Plastic, cloth, glass and dry air are good insulators. Other materials have some loosely held electrons, which move through them very easily. These are called conductors. Most metals are good conductors.

How can we move electrons from one place to another? One very common way is





to rub two objects together. If they are made of different materials, and are both insulators, electrons may be transferred (or moved) from one to the other. The more rubbing, the more electrons move, and the larger the static charge that builds up. (Scientists believe that it is not the rubbing or friction that causes electrons to move. It is simply the contact between two different materials. Rubbing just increases the contact area between them.)

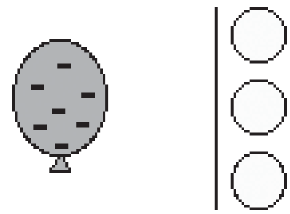
Static electricity is the imbalance of positive and negative charges.

Opposites Attract static charges.

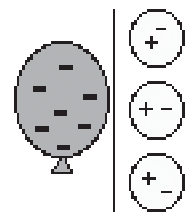
Now, positive and negative charges behave in interesting ways. Did you ever hear the saying that opposites attract? Well, it's true. Two things with opposite, or different charges (a positive and a negative) will attract, or pull towards each other. Things with the same charge (two positives or two negatives) will repel, or push away from each other.

A charged object will also attract something that is neutral. Think about how you can make a balloon stick to the wall.

If you charge a balloon by rubbing it on your hair, it picks up extra electrons and has a negative charge. Holding it near a neutral object will make the charges in that object move.



Balloon stuck to wall



If it is a conductor, many electrons move easily to the other side, as far from the balloon as possible.

If it is an insulator, the electrons in the atoms and molecules can only move very slightly to one side, away from the balloon.

In either case, there are more positive charges closer to the negative balloon.

Opposites attract. The balloon sticks. (At least until the electrons on the balloon slowly leak off.) It works the same way for neutral and positively charged objects.

So what does all this have to do with static shocks? Or static electricity in hair?

When you take off your wool hat, it rubs against your hair. Electrons move from your hair to the hat. A static charge builds up and now each of the hairs has the same positive charge.

Remember, things with the same charge repel each other. So the hairs try to get as far from each other as possible. The farthest they can get is by standing up and away from the others. And that is how static electricity causes a bad hair day!

http://www.sciencemadesimple.com/static_electricity.html

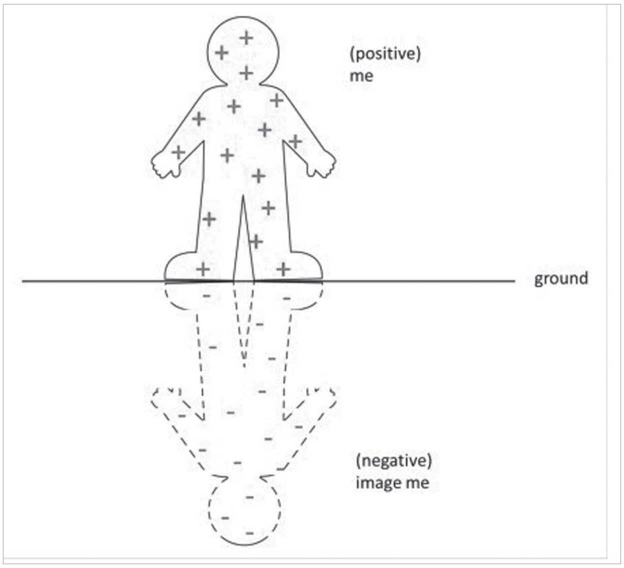
What if I were 1% charged?

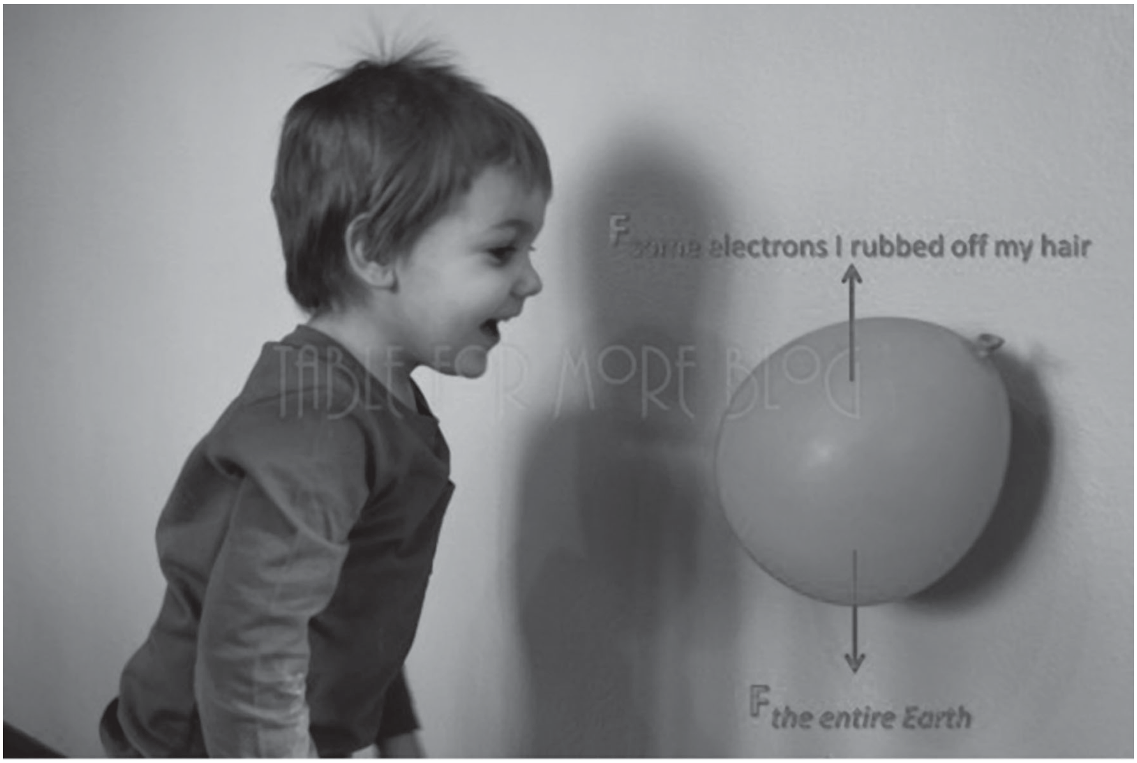
Brian Skinner

When it comes to understanding nature at almost any level larger than a nucleus and smaller than a planet, only one of them really matters: the Coulomb interaction.

The Coulomb interaction — the pushing and pulling force between electric charges — is almost incomprehensibly strong. One common way to express this strength is by considering the forces that exist between two electrons. Two electrons in an otherwise empty space will feel pulled together by their mutual gravitational attraction and pushed apart by the Coulomb repulsion. The Coulomb repulsion, however, is stronger than gravity by 4,000,000,000,000,000,000,000,000,000,000,000,000,000,000 or 10^{42} times. (For two protons, this ratio is a more pedestrian 10^{36} times.)

You can demonstrate this point in the following way. Take a balloon, and rub it against the top of your head until your hair starts to stand on end. Then stick the balloon to the ceiling, where it stays without falling due to static





electricity. Now consider the forces acting on the balloon. Pulling up on the balloon are electric forces between the relatively few electrons I just rubbed off from my hair and the opposite charge that they induce in the ceiling. Pulling down on the balloon are gravitational forces coming from the pull of the entire mass of the Earth. Apparently the electric force created by those few (something like 10^{10}) electrons is more than enough to counterbalance the gravitational pull coming from every proton, neutron and electron in the planet below it (something like 10^{51} of them).

So electric forces are strong. Why is it, then, that we can go about our daily lives without worrying about them buffeting us back and forth?

The short answer is that they *do* buffet us back and forth. Pretty much any time you feel yourself being pushed or pulled by something (say, the ground beneath your feet or the muscles tied to your skeleton), the electric repulsion between microscopic charges is ultimately to blame.

But a better answer is that the very strength of electric forces is responsible for their seeming quietude. Electric forces are so tremendously strong that nature will not abide having a large amount of electric charge collect in one place. And so electric forces, at the scale of people-sized objects, are largely neutralized.

But what if they weren't? What would happen if your body suddenly lost 1% of its electrons?

Now, 1% may not sound like a big deal. After all, there is almost no reason for excitement or concern when you lose 1% of your total mass. But losing 1% of your electrons, without at the same time losing a equal number of protons, means that suddenly, within your body, there is an enormous amount of positive, unneutralized electric charge. And nature will not abide its strongest force being so unrequited.

Suppose your body has a mass of about 40 kg, which means that it contains something like 2 times 10^{28} protons, and an almost exactly equal number of electrons. Losing 1% of those electrons would mean that your body acquires an electric charge of 2 times 10^{26} electron charges. Since each electron has a charge of 1.6 times 10^{-19} Coulombs, this is about 4 times 10^{7} Coulombs or 40 million coulombs.

Now, 40 million Coulombs is a silly amount of charge. An average bolt of negative lightning carries an electric current of 30,000 amperes (30 kA), and transfers about 15 Coulombs of electric charge. So this is about 3 million times more than what gets discharged by a lightning bolt, for example. So, in some sense, losing 1% of your electrons would be like getting hit by 3 million lightning bolts at the same time.

Things get even more dramatic if you start to think about the forces involved.

Suppose, for example, that in their rush to escape your body, those 40 million Coulombs split in half and flowed to opposite extremities. Say, each hand suddenly acquired a charge of 20 million Coulombs. The force between those two hands (spread apart, about 2 meters) would be 10^{25} Newtons. Needless to say, your body would not retain its structural integrity.

Of course, in addition to the forces pushing the extremities of your body apart, there would also be a force similar in magnitude pulling you toward the ground. You may recall that when an electric charge is next to a grounded surface (like, say, /the ground/) it induces some opposite charge on that surface in a way that acts like an image charge of opposite sign. In my case, the earth would accumulate a huge amount of negative charge around your feet so as to create a force like that of an image you.

Because of 40 million Coulombs, the force between you and your image self would be something like 10^{21} tons. To give that some perspective, consider that something with the same mass as the planet earth weighs only about 10^{21} tons!

The moral of this story, of course, is that nothing of observable size will ever get 1% charged. The Coulomb interaction cannot be thus toyed with. All of chemistry and biology function by the interactions between just a few charges at a time, and their effects are plenty strong as they are.

Adapted from the Blog "Gravity and Levity", by Brian Skinner; <https://gravityandlevity.wordpress.com>

Rounding and Estimation

Rounding and estimation are important skills in math and every day life. Rounding is a handy tool in the business world for working with amounts. People in a meeting might not want to worry about the exact value of 97. To make things easier, they all agree to round that number up to 100. Its' a lot easier to work with values when they have values rounded to the nearest ten, hundred, or whatever.

In math, you can use estimation to give you an idea about the possible answer without doing a lot of work. While you solve the full problem, you will know if you're on the right track. In daily life, estimation is great for giving intelligent guesses about possible amounts. You might see a pile of boxes and estimate that there are about 2,500 toys. It's okay if the actual number is 2,479. You were close enough for a quick idea.

Rounding Basics

In math, you can round up or round down. Rounding up happens when you have a value that is half or greater of the amount you are rounding. Let's say you want to round to the nearest ten. If you were given the value 26, you would round up because 6 is greater than half of ten (5). If you were given 25, you would also round up. Rounding down happens when the value is less than half. Using the same examples, if you were given the number 24 you would round down because the four is less than five. Even if you were given the wacky decimal 24.9999, you would still round down because 4.9999 is less than five. Here are some more examples:

Round 34 to the nearest 10 — 30

Round 678 to the nearest 10 — 680

It works for hundreds and thousands too.

Round 494 to the nearest 100 — 500

Round 627 to the nearest 100 — 600

Round 5,872 to the nearest 1,000 — 6,000

Round 8,452 to the nearest 1,000 — 8,000

Estimation Basics

Estimation is a process based on the rounding of numbers. Estimation is often used when you are doing arithmetic with long numbers. If you had the problem 567 + 248 and you only needed a close answer, you could estimate. That example might have you changing the values to 600 + 200 or 570 + 250. Your teacher would tell you where to round off (10s or 100s). Your first step was to round off both numbers to a specific place, and then you do the math. Your answer would be an estimation of the actual answer. You need to remember that estimation can give you answers that are very different from the actual answer. In our example, you might have estimated 800 or 820. With the actual answer of 815, you can see how the estimations were a bit off. Here are two more examples:

237 + 469 = ?

Rounding to 10: 240 + 470 = 710

Rounding to 100: 200 + 500 = 700

Actual answer: 706

864-202 =?

Rounding to 10: 860 - 200 = 660

Rounding to 100: 900 - 200 = 700

Actual Answer: 662

In the first example you were pretty close in either try. The second example shows how far off you can be from the actual answer. 700 is nowhere near the real answer of 662.

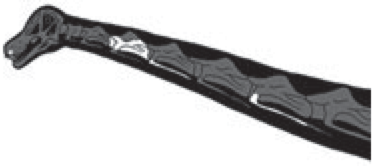
Introducing the Heavyweight Dino of the World

Dreadnoughtus schrani's tail alone measures an impressive 30 feet.

Erik Ness

After four years of excavation and five years of study, Dreadnoughtus schrani debuted in September as a top contender for the largest land animal ever: 65 tons and 85 feet long, with a 37-foot neck and muscle-bound 30-foot tail.

Paleontologist Kenneth Lacovara first spotted just a small patch of exposed bone one morning in February 2005 in Argentine Patagonia. Lacovara and fellow Drexel University researchers quickly returned, and by nightfall they had uncovered a 6-foot-long femur. “We knew immediately that we were looking



Kenneth Lacovara stands amid the skeleton of the massive Dreadnoughtus schrani in Argentina.

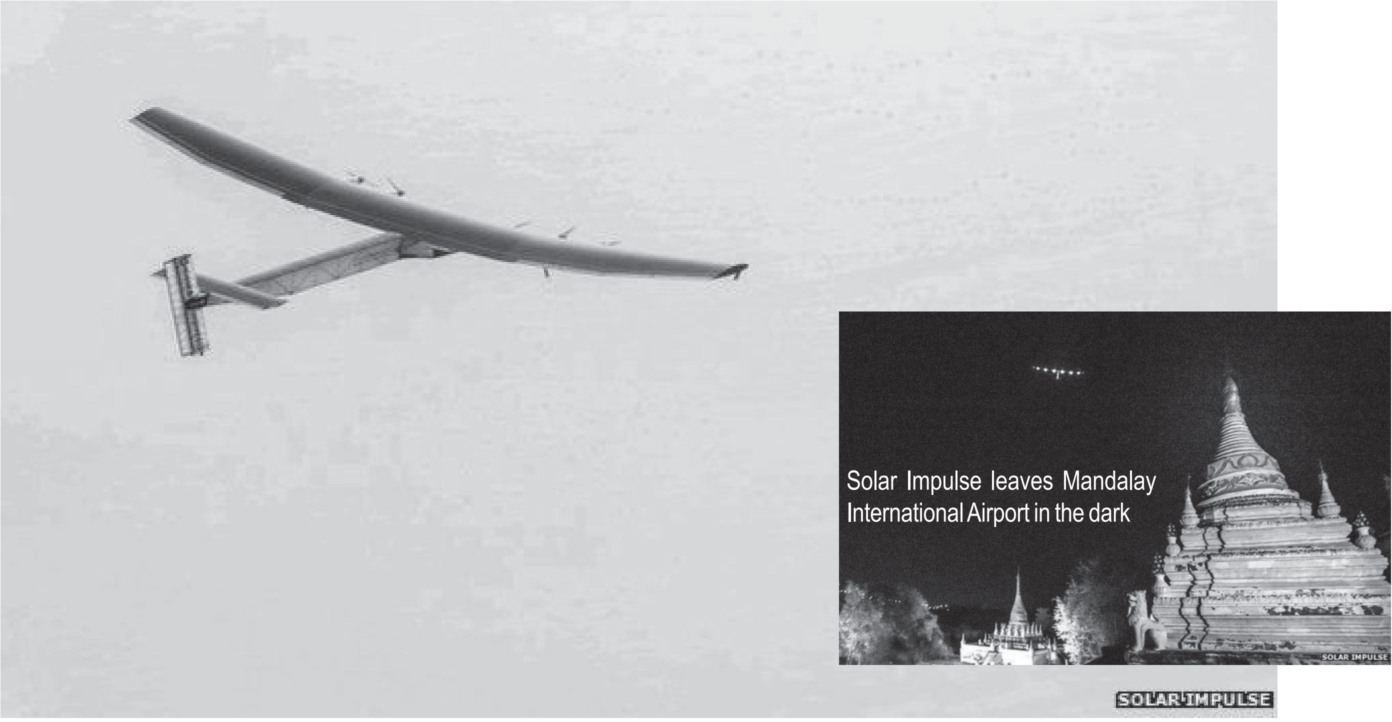
at one of the largest known dinosaurs," says Lacovara.

Dreadnoughtus lumbered through fern-filled forests between 66 million and 85 million years ago, and it left an astonishingly complete fossil: Almost half of the bones, 145, were recovered. Argentinosaurus, presumed to be the largest titanosaur, is known based on just 13 bones.

"Until Dreadnoughtus, we could only guess at the body proportions of supermassive dinosaurs," says Lacovara, author of the study, which was published in Scientific Reports. Scars indicate where tendons attached to the "exquisitely preserved" bones and will allow analysis of its musculature.

The Drexel team has released 3-D image files of Dreadnoughtus, making it the first new species presented along with its open-access virtual skeleton. "Any scientist or kid in the world can, to a substantial degree, see just what we were seeing," Lacovara says.

http://discovermagazine.com/2015/jan-feb



Solar Impulse leaves Mandalay International Airport in the dark

Solar Impulse plane lands in China

Jonathan Amos

Solar Impulse, the fuel-free aeroplane, has completed the fifth leg of its round-the-world flight. The picture above shows the familiar line of LEDs on the front of the plane as it comes into Chongqing, China

The vehicle, with Bertrand Piccard at the controls, touched down in Chongqing in China just after 17:30 GMT.

It had left Mandalay in Myanmar (Burma) some 20 hours previously.

The intention had been to make the briefest of stops in Chongqing before pushing on to Nanjing in the east of the country, but that strategy has been abandoned because of weather concerns.

The team will now lay over in southwest China until a good window opens up on the east coast at some point during the coming days.

Getting to the city of Nanjing would set up Solar Impulse to make its first big ocean crossing - a five-day, five-night flight to Hawaii.

Leg five proved to be a tough one for Bertrand Piccard. He had to cover a distance of 1,375km, and faced some difficult winds as he approached Chongqing Jiangbei International Airport. Local controllers also asked the Swiss pilot to delay his arrival for a short while because of the pressure of commercial traffic.

It is almost three weeks since the venture got under way from Abu Dhabi.

The project expects the circumnavigation of the globe to be completed in a total of 12 legs, with a return to the Emirate in a few months' time.

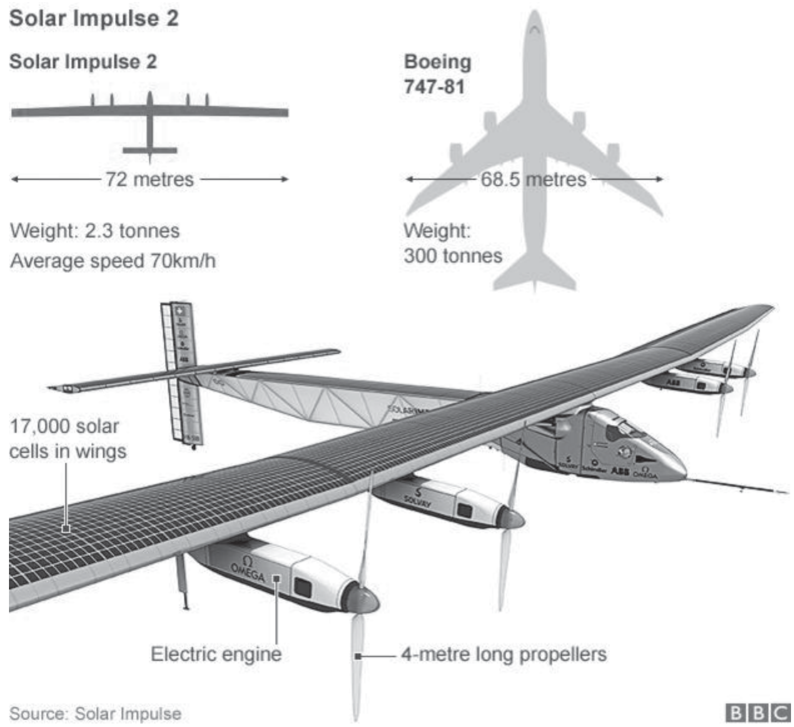
Bertrand Piccard is sharing the flying duties in the single-seater plane with his business partner, Andre Borschberg.

Solar Impulse has set two world records for manned solar-powered flight on the journey so far.

The first was for the longest distance covered on a single trip - that of 1,468km between Muscat, Oman, and Ahmedabad, India.

The second was for a groundspeed of 117 knots (216km/h; 135mph), which was achieved during the leg into Mandalay, Myanmar, from Varanasi, India.

No solar-powered plane has ever flown around the world.



Solar Impulse 2: 35,000km journey around the world

Source: Solar Impulse

A flooded street in Amritsar, after heavy monsoon rainfall struck the northern Indian city

Indian monsoon's past analysed by scientists

Helen Briggs

Fossils from the ocean floor are yielding clues to the Indian monsoon millions of years ago.

Samples drilled from beneath the Indian Ocean are being used to reconstruct past rainfall and temperature records.

Scientists are studying how the Indian monsoon behaved in the past, to shed light on the impact of climate change.

The research will lead to a better understanding of how the monsoon over India might change, said Dr Kate Littler of the University of Exeter.

As part of the larger-scale Asian monsoon, the monsoon over India is formed due to intense heat from the Sun in late spring, which warms the Northern Indian Ocean, along with the plains of northern India and the Tibetan Plateau.

This results in 75% of the year's rain falling between June and September.

Simulations of future climate generally suggest a 5-10% increase in monsoon rainfall over India, which could influence the economy and agriculture.

Palaeoclimatology - the study of changes in climate taken on the scale of the entire history of Earth - can give valuable clues to how the Earth might respond to future climate change.

Dr Littler was part of an expedition to the Indian Ocean, Bay of Bengal and the Andaman Sea on a scientific drill ship belonging to the UK International Ocean Discovery Program.

The team of international scientists collected sediment samples from the deep-sea at several locations.

These are being analysed to reconstruct what the regional and global climate was like during the period when the small fossilised marine creatures contained in the sediments lived.

Kate Littler with the sediment cores

"We wanted to capture the whole evolution of the India monsoon from when it intensified about 8 million years ago," said Dr Littler.

"By analysing these hard-to-reach deep-sea sediments we will make important discoveries about the behaviour of the Indian monsoon in the deep past, and how its behaviour and intensity may change in the near future.

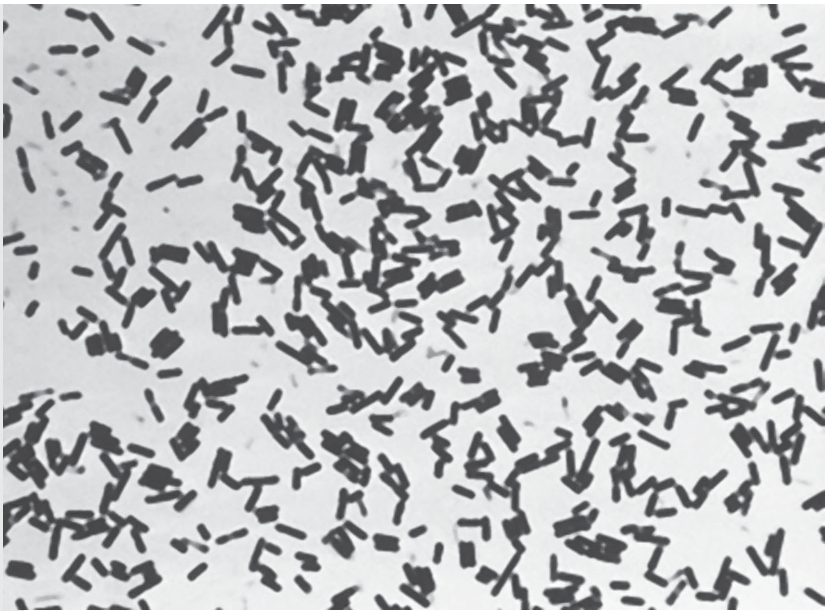
"The data will give us a holistic idea of the past behaviour of the monsoon."

Some of the samples came from sites that had never been drilled before.

Others contained volcanic ashes, which can be matched to ancient volcanic eruptions, helping in dating the sediments.

Their chemistry, geology and biology will be analysed to build up a record of how the annual Indian monsoon cycle has historically been affected by climate change.

SOIL BIOLOGY



Soil is full of life. It is often said that a handful of soil has more living organisms than there are people on planet Earth. Soils are the stomach of the earth, consuming, digesting, and cycling nutrients and organisms.

On first observation, however, soil may appear as a rather inert material on which we walk, build roads, construct buildings, and grow plants. On closer observation, we observe that soil is teeming with living organisms. Living organisms present in soil include archaea, bacteria, actinomycetes, fungi, algae, protozoa, and a wide variety of larger soil fauna, including springtails, mites, nematodes, earthworms, ants, insects that spend all or part of their life underground, and larger organisms such as burrowing rodents. All of these are important in making up the environment we call soil and in bringing about numerous transformations that are vitally important to life.

WHAT DO SOIL BIOLOGISTS STUDY?

The links between soil organisms and how they impact soil chemical and physical properties is complex. Soil biologists study a variety of things.

Soil bacteria

There are thousands of different types of bacteria, that can both help and harm people.

Only 5% of what is produced by green plants is consumed by animals, but the 95% is consumed by microorganisms. One gram of fertile soil can contain up to one billion bacteria. There are many different types of bacteria, and most of them have not even been discovered yet! Most of these bacteria are aerobic, meaing that they require oxygen from the soil atmosphere. However, other bacteria need to live without oxygen, and other types can live both with, and without oxygen. The growth of these bacteria is limited by the food that is available in the soil.

Soil fungi are also large component of the soil that come in various sizes, shapes, and colors. Mushrooms have underground roots (mycelium) that absorbs nutrients and water until they are ready to flower in the mushroom form. They tolerate acidity, which makes them very important to decompose materials in very acidic forests, that microbes cannot do, they can also decompose *lignin*, which is the woody tissues for decomposing plants.

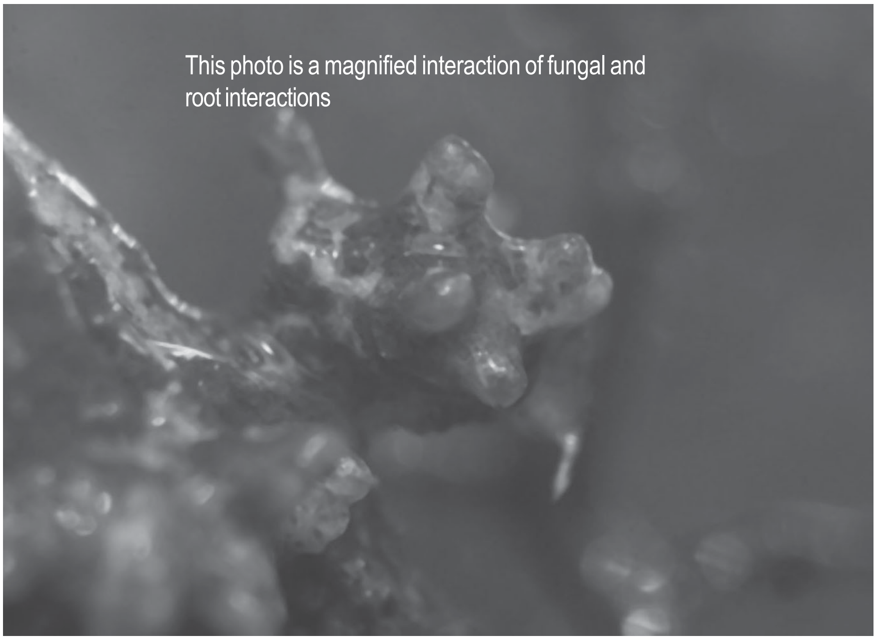
Soil Animals

Soil animals are consumers and decomposers because they feed on organic matter and decomposition occurs in the digestive tract. Some animals feed on roots, and others feed on each other. There are several types of worms. Earthworms are the easiest to identify. They eat plant material and organic matter, and excrete worm castings in the soil as food for other organisms. They also leave channels that they burrow in, which increases infiltration. Earthworms can weigh between 100-1,000 pounds per acre! There are also microscopic worms called nematodes, or roundworms. These worms live in the water around soil particles. There are several different types of nematodes, some of them eat dead materials, others eat living roots, and some eat other living organisms. Some nematodes are bad, and can cause severe root damage or deformation.

Aside from worms, another large body of insects are arthropods that have exoskeletons and jointed legs. These include mites, millipedes, centipedes, springtails, and grubs.

Carbon and Nutrient Cycling

Nurtient Cycling is the exchange of nutrients between the living and nonliving parts of the ecosystem. Soil biologists measure how plants and microbes absorb nutrients, and incorporate them into organic matter, which is the basis for the carbon cycle. There are two main processes. Immobilization is when soil organisms take up mineral nutrients from the soil and transform them into microbial and plant tissues. The opposite process is mineralization, which is what happens when organism die and release nutrients from their tissues. This process is rapidly changing, and very important in providing nutrients for plants to grow. The carbon cycle and nitrogen cycle are both very



This photo is a magnified interaction of fungal and root interactions important to soil microbiologists.

Soil Microbe and Organism Interactions

Plant roots leak a lot of organic substances into the soil from dead materials. These provide food for the microorganisms, and create zones of activity around the root called the rhizosphere. In this zone, plant growth or toxic substances can be produced, but most of these organisms are benefical.

Other scientists study soil diseases of plants and animals found in the soil. Bacteria and fungi can cause plants to wilt or rot. The Great Potato Famine in Ireland in 1845 was caused by a fungus that caused the potato blight! These organisms don't just impact plants. Humans can get sick if certain types of bacteria, like E-Coli, are present in our waste, and that waste isn't treated properly.

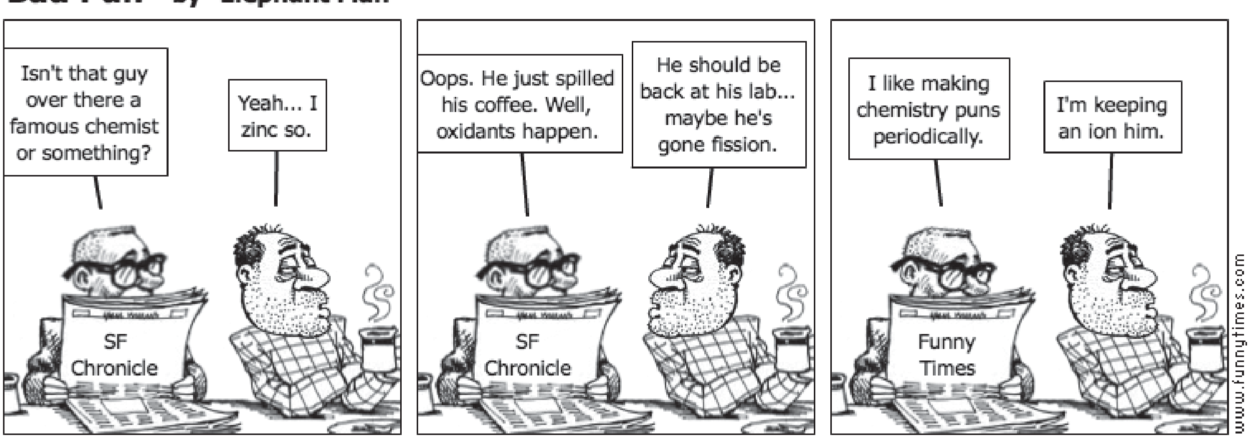
Some fungi "infect" plant roots, but the relationship is symbiotic, meaning that it is beneficial to both the plant and the root. These are called mycorrhiza, and they help plants absorb more water and nutrients, increase drought resistance, and reduce infection by diseases.

Another symbiotic relationship involves nitrogen. There is a lot of nitrogen in the atmosphere, but it is not easy for plants to get. There are certain species of bacteria that absorb nitrogen gas from the atmosphere, and form a nodule. These are called nitrogen fixing bacteria. When the die, the nitrogen that they used are released for plants.

http://www.soils4teachers.org/biology-life-soil

"Well, it certainly looks like your DNA. How many times have I told you to wear gloves before touching anything?"

Bad Pun by Elephant Man



Do you know?

1. If you fall asleep and start dreaming, and in the dream you are awake, do you still get a good night's sleep?.

2. Can little chicks (of birds) count ?

3. Is it true that stress experienced by a pregnant womancan affect the health of the foetus inside her ?

4. Do sporting performance of athletes vary at different times of day ?

5. Is the use of 'smart' phones chaning the way our brains function ? If yes, is it permanent ?

6. By testing a person's tears, can we find out if it was caused by pain or by emotion ?

Answers to DYK questions asked in last issue

1. Do we really need vitamins?

Vitamins are essential for human life, but are only needed in small amounts. They all play very different roles but essentially help cells in your body to read your DNA correctly, allow proteins like enzymes to work properly and reduce the damage to your body caused by stress.

Minerals are mostly metal elements like zinc and iron whereas vitamins are molecules made up of carbon, oxygen, hydrogen, and sometimes nitrogen. These four elements are the most abundant in the human body, but because we do not have the right biochemical machinery to make vitamins from scratch, we need to get them from our diet.

Some vitamins like A and B12 can be stored in the body, usually in the liver. But others such as zinc must be constantly supplied in your food.The reason that some nutrients can be stored and others cannot is due to their solubility. Fat soluble nutrients like vitamin A can be stored whereas water soluble ones like vitamin C are too readily excreted to keep hold of.

Severe vitamin deficiencies can cause dramatic visible effects such as loss of hair, skin cells, birth defects and even death. But even mild deficiency may cause (for example) slow growth, poor eyesight, weak immunity and decreased resistance to

cancer and heart disease.

So yes, we do really need to take vitamins.

2. Why are colds more common in winter ?

Firstly is it true that colds are more common in winter ? For decades, doctors used to dismiss this as a myth. But now, scientists have demonstrated that winter weather really can increase your chances of catching a cold.

When the cells in our noses are infected with viruses, they sound a chemical alarm to help other cells to fend off infection. But at lower temperatures, this does not work so well, giving an attacking virus an advantage. This partly explains why the common cold virus or the rhinovirus replicates at a cooler temperature found in the nose.

Scientists could not grow the virus well at the typical body temperature of 37 degrees C, but when they reduced the temperature of the incubator to 33 degrees, the virus could grow. This was already known in the 1960's but finding out why took time.

Scientists have been studying molecules known as sensors that detect virus RNA inside mice cells. They took away the sensors, and saw that the virus could now grow even at the higher temperature of 37 degrees, indicating that it is the host's immune response that dictates which temperature the virus can grow in.

Why nose especially and not in other parts of the body ? The rhinovirus actually prefers to replicate in the nasal cavity because it is easy to transmit the virus from the nose to the next person by either touching the nose or sneezing or other means.

There is another problem. Not only do the sensors of the virus not work well at the lower temperature, but also the interferons that are produced as a result of the sensing do not stimulate the neighbouring cells as well. These interferons are molecules that are secreted from infected cells to try to alarm the neighbouring cells from becoming infected by the virus. In the nasal cavity temperature, the alarm system also does not work very well.

So to prevent colds, we need to raise nose temperatures somehow !

3. Why cannot aeroplanes fly faster than they do ?

Passenger jets fly at speeds close to nearly 900 KM per hour. Can they not go faster ? Yes, but then why don't they ?

The short answer is that speed costs fuel

and money. If you are driving a car at 60 KM an hour and then accelerate to 120 KM an hour, what happens to fuel consumption? It goes up. The same is true on an aircraft. The faster you go, the more fuel you burn. Drag, which causes the increase of fuel burnt, is actually proportional to the square of the speed. In fact, the energy to overcome drag is proportional to the cube of the speed. Thus drag increases at a faster rate than increasing speed.

If you want to just get there more quickly, you have to pay for it. One of the biggest costs for an airline of course is fuel, therefore the likelihood of us designing a supersonic aircraft for major commercial flying is probably not going to happen any time soon.

Another advantage of decreasing fuel burnt is it means less carbon dioxide emissions, less nitrous oxide emissions and less noise too.

4. All life must end eventually. How will life end on Earth?

Life is truly persistent. Scientists in the American space agency NASA tried to create a sterile room to build Mars rovers to prevent interplanetary contamination. What did they find ? Bacteria that evolved to eat the paint in the sterile room. So, will life always find a way to endure, no matter what happens to Earth?

We know that the sun will die in about 6 billion years. When that happens, it will flare up, become a red giant and engulf the inner planets and end any life remaining on Earth. Long before that, in fact, life would have become uncomfortable on Earth because the sun would be getting brighter all the time. So after about 1 billion years from today, the ocean would start to boil.

But a billion years is a long time. If we consider that the Earth has ahead of it far more time than it has taken to go all the way from simple organisms to humans, then we can also imagine that by the time the sun dies, there will be life descended from human life, all through the galaxy perhaps and taking many different forms. So, human life may end on Earth but not elsewhere in the universe.

5. I saw a film of a scuba diver swimming under water. What would happen if a scuba diver was swallowed by a whale?

Orcas, also known as killer whales, are in the dolphin family. However, an orca's gapin wide mouth is probably big enough to engulf a human head, but not much more of the human body. A further restriction is the opening of the throat that is much smaller than the gape of the mouth. The throat is able to accommodate a large, whole salmon - perhaps about the size of a human thigh. Even the sperm whale has a relatively small throat opening, despite the wide gape of the lower jaw away from the rest of the head. So, an orca accidentally swallowing a human, especially one wearing a scuba tank, is like saying that you accidentally swallowed a watermelon whole ! It is physically impossible.

Moreover why would an orca want to consume a human ? Orcas may attack and kill humans out of fear and anxiety but would not eat them.

It is also doubtful whether the constrictive power of the orca's oesophagus

is enough to crush a whole, live person. The muscular layer of the oesophagus is not that thick.

Worse, the scuba gear, like the compressed gas tank, rubber hoses, gauges, and lead weight belts, would likely make the whale very sick indeed. The whale cannot digest them, it will try to pass the items out. However, these bulky items are likely to block the intestinal tract and cause death.

So we need not worry very much about a toothed whale swallowing scuba divers.

Source: Science Forum, Cambridge University

Science News

'Bright Spot' on Ceres Has Dimmer Companion

Feb 27, 2015: Dwarf planet Ceres continues to puzzle scientists as NASA's Dawn spacecraft gets closer to being captured into orbit around the object. The latest images from Dawn, taken nearly 29,000 miles (46,000 kilometers) from Ceres, reveal that a bright spot that stands out in previous images lies close to yet another bright area.

"Ceres' bright spot can now be seen to have a companion of lesser brightness, but apparently in the same basin. This may be pointing to a volcano-like origin of the spots, but we will have to wait for better resolution before we can make such geologic interpretations," said Chris Russell, principal investigator for the Dawn mission, based at the University of California, Los Angeles.

This image was taken by NASA's Dawn spacecraft of dwarf planet Ceres on Feb. 19 from a distance of nearly 29,000 miles (46,000 kilometers). It shows that the brightest spot on Ceres has a dimmer companion, which apparently lies in the same basin.

Using its ion propulsion system, Dawn will enter orbit around Ceres on March 6. As scientists receive better and better views of the dwarf planet over the next 16 months, they hope to gain a deeper understanding of its origin and evolution by studying its surface. The intriguing bright spots and other interesting features of this captivating world will come into sharper focus.

"The brightest spot continues to be too small to resolve with our camera, but despite its size it is brighter than anything else on Ceres. This is truly unexpected and still a mystery to us," said Andreas Nathues, lead investigator for the framing camera team at the Max Planck Institute for Solar System Research, Gottingen, Germany.

Dawn visited the giant asteroid Vesta from 2011 to 2012, delivering more than 30,000 images of the body along with many other measurements, and providing insights about its composition and geological history. Vesta has an average diameter of 326 miles (525 kilometers), while Ceres has an average diameter of 590 miles (950 kilometers). Vesta and Ceres are the two most massive bodies in the asteroid belt, located between Mars and Jupiter.

NASA's Cassini and NSF's VLA Pinpoint Saturn With Exquisite Accuracy

Jan. 8, 2015: Scientists have paired NASA's Cassini spacecraft with the National Science Foundation's Very Long Baseline Array (VLBA) radio-telescope system to pinpoint the position of Saturn and its family of moons to within about 2 miles (4 kilometers). The measurement is some 50 times more precise than those provided by ground-based optical telescopes. The feat improves astronomers' knowledge of Saturn's orbit and benefits spacecraft navigation and basic physics research.

The team of researchers used the VLBA -- a giant array of radio-telescope antennas spread from Hawaii to the Virgin Islands -- to pinpoint the position of Cassini as it orbited Saturn over the past decade by receiving the signal from the spacecraft's radio transmitter. They combined this data with information about Cassini's orbit from NASA's Deep Space Network. The combined observations allowed the

scientists to make the most accurate determinations yet of the position of the center of mass, or barycenter, of Saturn and its numerous moons.

Researchers have determined the location of the Saturn system's center of mass to within just a couple of miles (or kilometers), a factor of 50 improvement over previous knowledge.

The study team included researchers from NASA's Jet Propulsion Laboratory in Pasadena, California, and the National Radio Astronomy Observatory (NRAO) in Socorro, New Mexico. The scientists are presenting the results of their work today at the American Astronomical Society's meeting in Seattle.

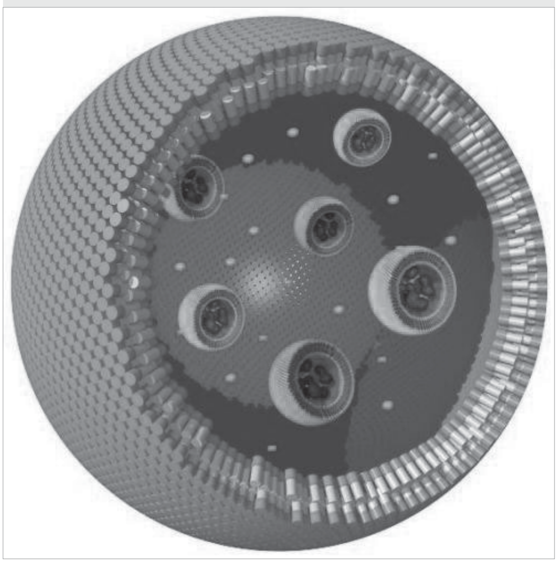
The new measurement was made possible by two factors: Cassini's long-term presence in the Saturn system and the VLBA's ability to discern extremely fine detail. The result is a greatly improved table of predicted positions of objects in the Saturn system, known as an ephemeris. An ephemeris is one of the basic tools of astronomy.

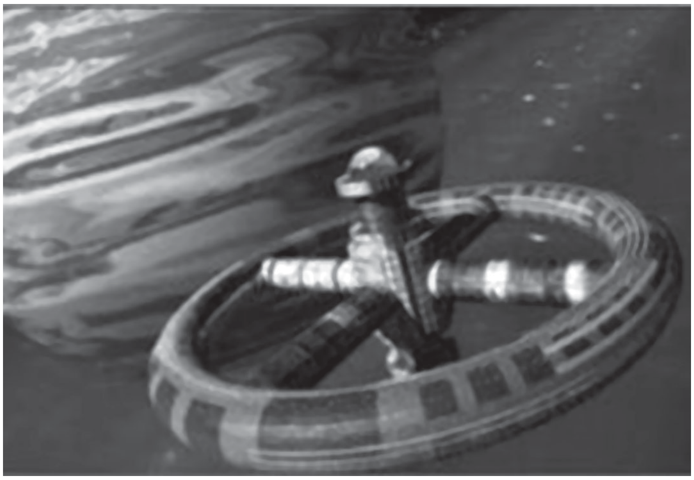
"This work is a great step toward tying together our understanding of the orbits of the outer planets of our solar system and those of the inner planets," said Dayton Jones of JPL, who led the study.

The improved positional information will help enhance precise navigation of interplanetary spacecraft and help refine measurements of the masses of solar system objects. It will also improve predictions of when Saturn or its rings will pass in front of background stars -- events that provide a variety of research opportunities for astronomers.

First Plastic Cell Made With Working Parts

For something so tiny, a biological cell is a remarkably crowded place. In multi-celled creatures known as eukaryotes, each cell is packed with even smaller structures—organelles—that have specific functions, often related to controlling chemical reactions. To better understand cell chemistry, scientists at Radboud University Nijmegen in the Netherlands created the first artificial cell with actual working parts inside. They trapped tiny spheres filled with enzymes inside a water droplet and coated the whole thing with a polymer. The resulting "plastic cell," described in the January issue of Angewandte Chemie, initiated a cascade reaction among the enzymes inside, essentially mimicking the way organelles function.





China plans huge solar power station in space

BEIJING: China plans to build a huge solar power station 36,000km above the ground in an attempt to battle smog, cut greenhouse gases and solve energy crisis, much on the lines of an idea first floated in 1941 by fiction writer Isaac Asimov, state media reported on Monday.

If realized, it will surpass the scale of the Apollo project and the International Space Station, and be the largest-ever space project.

The power station would be a super spacecraft on a geosynchronous orbit equipped with huge solar panels. The electricity generated would be converted to microwaves or lasers and transmitted to a collector on Earth, staterun Xinhua news agency reported.

In 1941, American science fiction writer Isaac Asimov had published a short story "Reason", in which a space station transmits energy collected from the sun using microwave beams.

Wang Xiji, an academician of the Chinese Academy of Sciences and an International Academy of Astronautics member, says Asimov's fiction has a scientific basis.

After devoting over 50 years to space technology research, Wang, 93, is an advocate for the station: "An economically viable space power station would be really huge, with the total area of the so lar panels reaching 5 to 6 sq km."

That would be equivalent to 12 of Beijing's Tian'anmen Square, the largest public square in the world."Maybe people on Earth could see at night, like a star," says Wang.

Wang says the electricity generated from the ground-based solar plants fluctuates with night and day and weather, but a space generator collects energy 99% of the time.Space-based solar panels can generate ten times as much electricity as ground-based panels per unit area, says Duan Baoyan, a member of the Chinese Academy of Engineering."If we have space solar power technology", hopefully we could solve the energy crisis on Earth," Duan said. Wang says whoever obtains the technology first "could occupy the future energy market." However, many hurdles lie ahead: A commercially viable space power station would weigh 10,000 tons. But few rockets can carry a payload of over 100 tons to low Earth orbit. "We need a cheap heavy-lift launchvehicle," says Wang, who designed China's first carrier rocket more than 40 years ago. "We also need to make very thin and light solar panels."

Li Ming, vice-president of the China Academy of Space Technology, says, "China will build a space station in around 2020, which will open an opportunity to develop space solar power technology."