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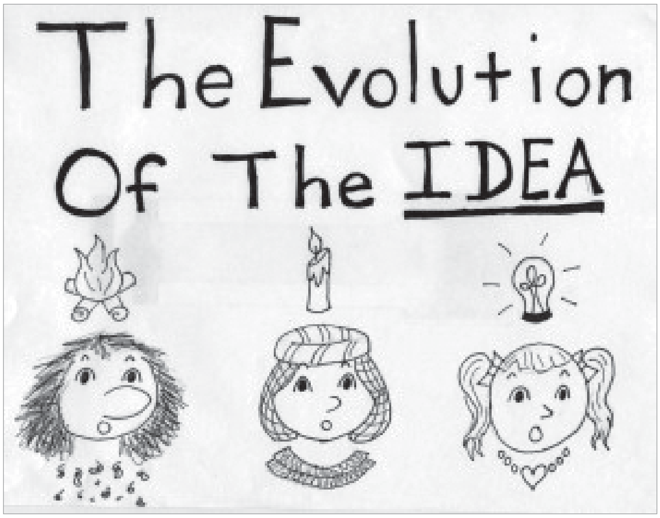
Front Cover: *Chamomile flowers are sweet-scented flowers that are very popular in Europe, especially Germany, to make chamomile tea. Photo: https://www.southernexposure.com*

Back Cover: *Saffron, or autumn crocus (Crocus Sativus) flower with orange-red stigmas and yellow stamens. The three orange stigmas of each flower are collected and dried to make saffron spice. Photo Credit: Wikimedia Commons.*

Back Cover: *Schematic of the Evolution of the Universe, with time passing from left to right. At any given time, the Universe is represented by a disk-shaped slice of the diagram. Credit: Wikimedia Commons.*



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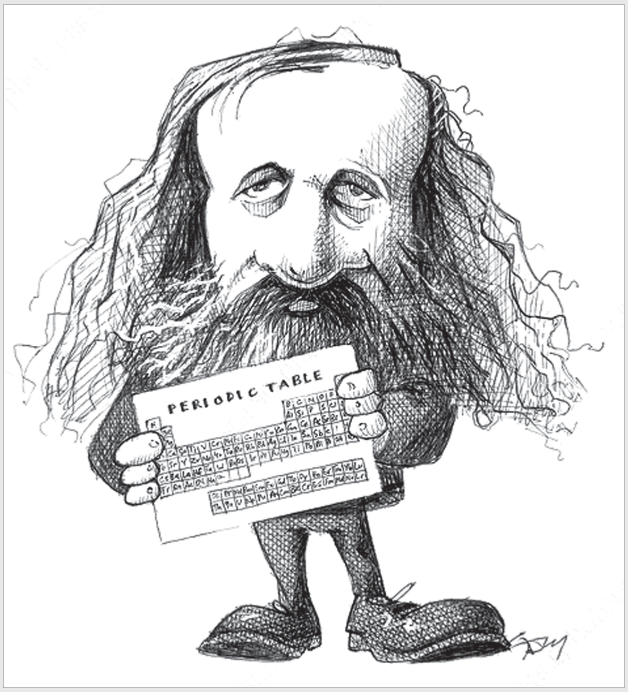


Nobel Prize in Physics 2019:

Modern Cosmology and Exoplanets

M.V.N. Murthy, Chennai

The 2019 Nobel prize has been announced. One half of the prize is awarded to **James Peebles** for "*theoretical discoveries in physical cosmology*" and the other half is shared equally by **Michel Mayor** and **Didier Queloz** for the "*discovery of an exoplanet orbiting a solar type star*". James Peebles was born in Winnipeg, Canada in 1935 and is presently Albert Einstein Professor of Science at Princeton University, USA.

The Big Bang

In 1912 **Vesto Slipher** observed that the light from distant galaxies was red-shifted (more about this later). This was confirmed by **Edwin Hubble** in 1929. The red-shift simply means that the remote galaxies are moving away from us. That is, the Universe is expanding for ever since its birth. Working backwards in time this obviously means that the Universe must have started extremely small and in a very hot state. The moment at which it all started is called the *Big Bang*, a name coined by **Fred Hoyle**.

James Peebles

Modern Cosmology

The real change came about in 1964 when **Arno Penzias** and **Robert Wilson** (Nobel Prize- 1978) were trying to study radio waves. But they could not remove the constant hum that their antenna picked up from every direction, night and day, no matter how much they tried. After many checks of their instruments, they concluded that this was not instrument noise as we often hear in a radio, but some thing coming from the space all around.

The breakthrough was provided when James Peebles immediately interpreted this hum as due to the radiation left-over from the Big bang. Today it is called the *cosmic background radiation*. Thus began the era of Modern Cosmology which is now almost entirely based on observations.

Michel Mayor *and* ***Didier Queloz***

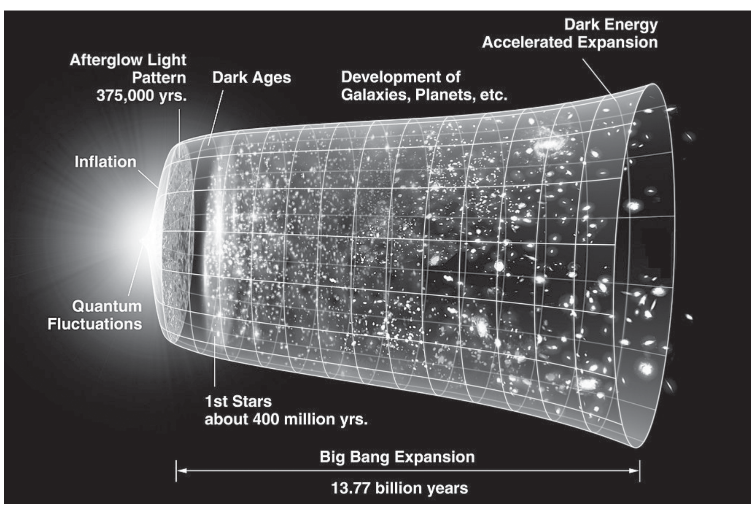
Evolution of the Universe

Today we have a deeper understanding of how the Universe evolved from the Big Bang into what it is today. The Universe began around 13.7 billion years ago in the Big Bang. In the beginning everything including gravity is in the quantum regime and we do not understand this phase that well even today.

Immediately after this phase, the Universe underwent a rapid, *exponential* expansion. That is, the size of the Universe became exponentially larger. This is called the *inflationary expansion* of the Universe.

The radiation at extremely high temperature interacts to produce a soup of elementary particles like quarks (which will eventually make up protons and neutrons in the nucleus of atoms) and leptons (electrons for example). As the universe expands the soup cools so that the quarks combine to form protons and neutrons. These then combine to form first the nuclei and then neutral atoms by capturing electrons.

Once the neutral matter is formed, about 375,000 years after the Big Bang, the radiation that is ever present decouples from ordinary neutral atomic matter and forms a permanent background. This is the Cosmic Microwave Background Radiation (CMBR) that Penzias and Wilson detected and James Peebles interpreted.



The temperature at which this radiation decoupled was still very high but over time as the Universe expanded, it cooed to its present temperature of 3 degree Kelvin or about -270 degree Celsius.

The neutral matter combines to form matter of all sizes and shapes like the stars, galaxies and every thing that we observe through telescopes. This is summarised in the schematic figure from WMAP observations by NASA.

More on the Cosmic Background Radiation

The observation of CMBR opened up a wealth of information from which we are now able to reconstruct much of the history of the universe. While the CMBR is more or less uniform in all directions, there are subtle variations or ripples in the radiation. But for these ripples, the universe would have been a ball of uniform distribution of matter and space. But the space is full of clumps of matter; these are the stars, galaxies, clusters of galaxies etc. The ripples therefore reveal the slight variations that survives from the early universe: whereever there was more density, stars and galaxies have formed.

Now, scientists have observed these tiny non-uniformities in the background radiation with increasing precision. We are now able to conclude that nearly 95 percent of the universe is almost invisible to us. All the matter that is visible to us is just above five percent, that is the matter that constitutes all the stars, planets, mountains and seas, and all living things.

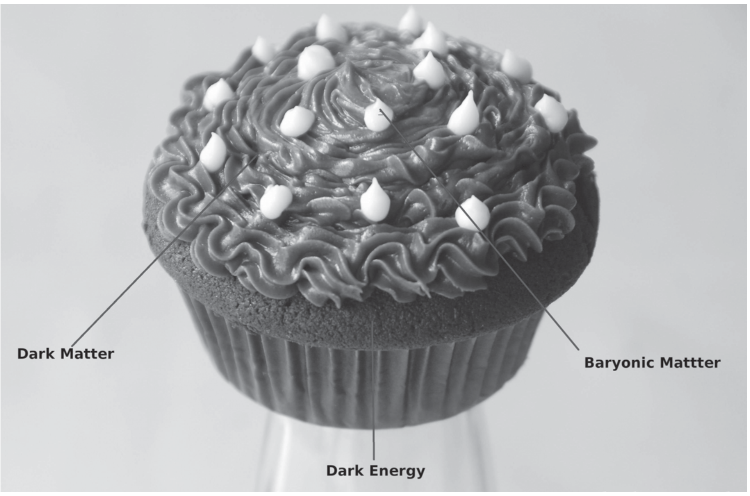
Dark Matter

About 25 percent of the rest is known as Dark Matter whose existence is known to us through its gravitational effect on the motion of stars and galaxies. The presence of dark matter is now well established through its gravitational effect on the motion of stars and galaxies. It is called dark since it does not emit any light (or em radiation). Peebles noted that if dark matter is made up of particles like our ordinary matter (electrons, protons, neutrons), then these particles must be at least ten times heavier than proton or neutron and probably much more. This is now called the cold dark matter. We still do not understand this very well.

Dark Energy

The rest, about 70 percent, which makes up the Universe, is callee dark energy. Very little is known or understood about this, but it is expected to drive the acceleration of the universe as established through observations in 1998 by **Perlmutter**, **Schmidt** and **Riess** (Nobel Prize 2011).

James Peebles is considered one of the founders of Modern Cosmology. Modern Cosmology is now an evidence-based science. Every step of our understanding of the universe and our place in it, has contributions from James Peebles. Unlike many other Nobel Prizes, this years prize honours contributions



of Peebles made over a period of more than four decades, much like the prize given to scientist **S. Chandrasekhar** earlier.

Exoplanets

Half the Nobel prize in 2019 is equally shared between **Michel Mayor** and **Didier Queloz** for their discovery of Exoplanets orbiting a star similar to our own sun. Michel Mayor was born in 1942 in Lausanne, Switzerland and is a professor at University of Geneva in Switzerland. Didier Queloz was born in 1966 in Geneva, Switzerland and is a professor at University of Geneva and also at University of Cambridge, UK.

There are about 10^{21} (one billion trillion) stars in the universe that is accessible to us for viewing. In fact there may be many more but we will never know since our observation is limited to a size of about 13.7 billion light years from Earth. Remember one light year is the distance travelled by light in a year. Given that there are such a large number of stars, is it possible that sun is the only star that has a planetary system?

Any reasonable answer, based on chance or probability, would be NO; there must be other star systems with planets. Such planets are called Exoplanets, that is planets outside our solar system. So we already have the answer to the question. So what is the big deal about this year's Nobel prize?

Difficulty of observation

Any object in the sky (stars, galaxies) is observed, using telescopes of various kinds, by the light it emits.

Planets do not emit light or glow of their own; they merely reflect the light from nearby stars. For example, we see other

Deadly Choice

A man is caught on the King's property. He is brought before the King to be punished.

The King says, "You must give me a statement. If it is true, you will killed by lions. If it is false, you will be killed by trampling of wild buffalo."

But in the end, the King has to let the man go.

What was the man's statement?

Answer on page 34

Doppler Effect

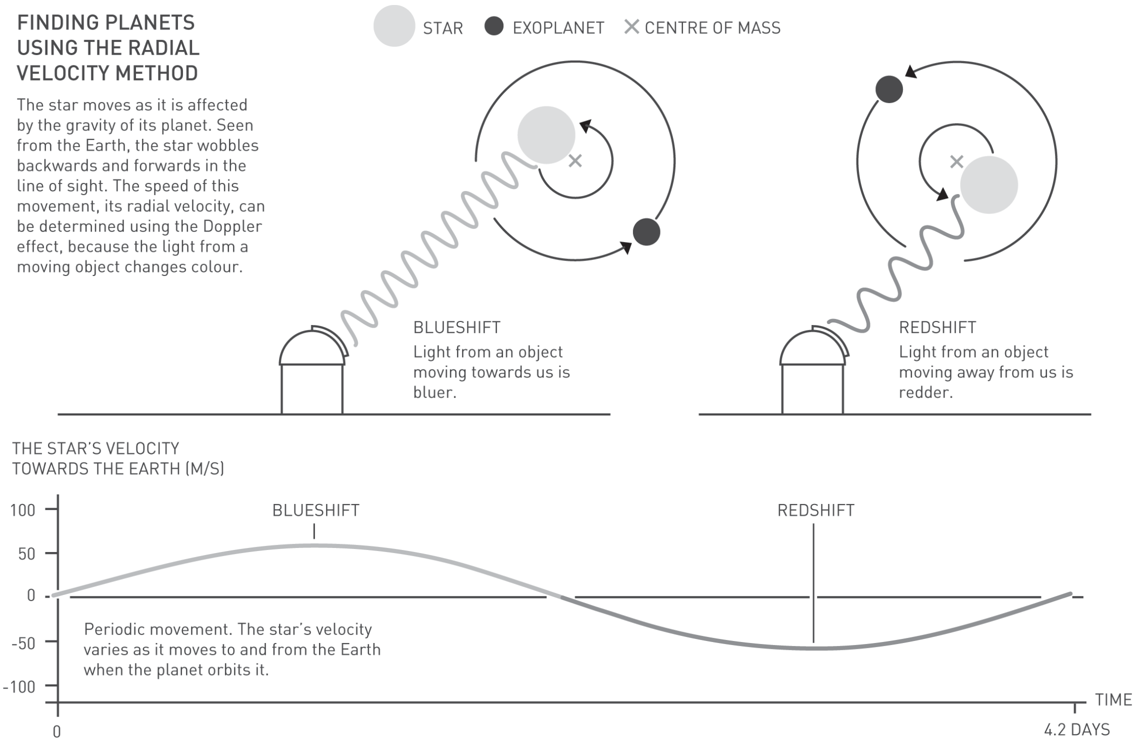
Doppler effect is actually familiar to all of us. If you are standing on a road and a truck is coming towards blaring the horn, you will actually hear a sound of higher frequency (shriller) than the actual frequency of the horn (when it is not in motion). Similarly when it is moving away the frequency of the sound is reduced. This is true of sound waves and also of light waves. If a star is moving towards the observer on earth then the frequency of light is shifted to higher frequency (called the blue shift) and if it is moving away from the observer then it is shifted to lower frequency (called the red shift). As a result of the Doppler effect, the colour of light emitted by the star keeps changing during its revolution around the center of gravity of star and planet system. This fact was used by the Nobel prize winners this year to identify the presence of an exoplanet.

planets (also comets) in the solar system since these planets scatter the light from the sun. Farther the planet, the fainter it becomes. Ultimately it becomes too faint to be observable over large distances (say of the order of light years) against the background of light emitted by stars themselves.

The radial velocity method

So how does one observe exoplanets? It requires sophisticated and precise methods to observe these exoplanets which is what Mayer and Queloz did. They used a method called the radial velocity method.

Suppose there is a planet orbiting a star (like our solar system). Not only does the



stars gravitational force keeps the planet in the orbit (remember Kepler), but the gravitational pull of the planet also affects the motion of the mother star. In fact both the star and the planet revolve around their common centre of gravity as shown in the figure.

Now here is the key: Even though the planet itself is not observable, its presence moves the star in a regular motion. For an observer looking through the telescope from earth, it would appear as if the star is moving towards us for half the time of revolution and moving away for the other half the time. This motion of the star, which to an observer on earth appears as simple motion either towards or away (radial motion) causes what is called Doppler effect (see Box).

It took a long time to identify the first exoplanet which was done finally in the year 1995.

So what were the challenges:

. The first challenge is to identify the region in the sky where there likely to be planetary systems. Mayor and Queloz identified the star ***51 Pegasi*** which is about 50 light years away from us. The first exoplanet is therefore called *51-Pegasi-b*.

. The next challenge is to have a star which has a revolution period (period of radial velocity) which is not too long so that many observations can be made. 51-Pegasi-b takes about four days to complete its orbit, which means it is very close to the host star.

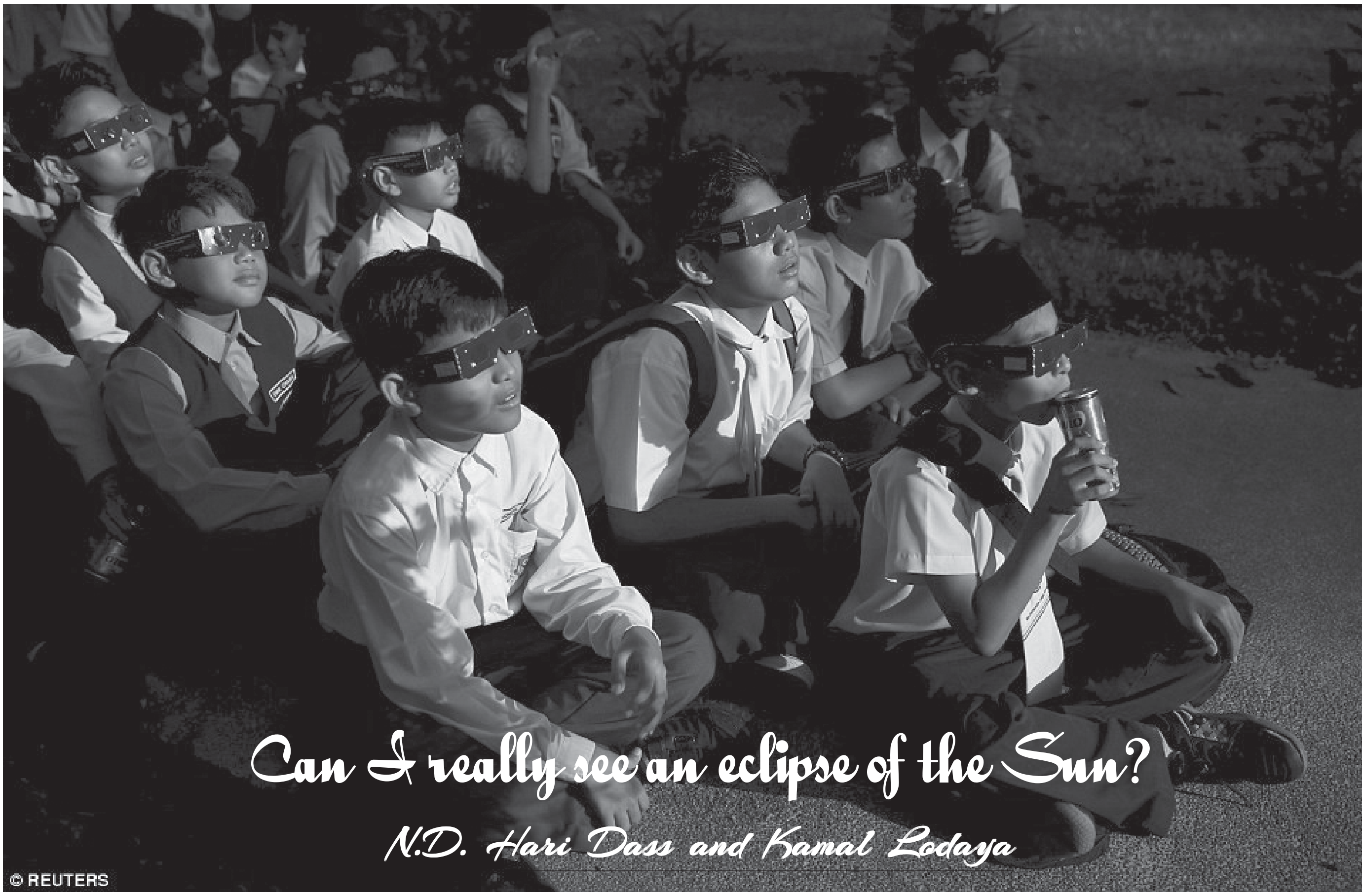
. The planet must have a bigger size to have sufficient impact on the stars radial motion. 51-Pegasi-b is indirectly estimated to be as large as our own Jupiter.

. The biggest challenge is measuring the changes in the frequency which are extremely small since radial velocities are extremely low. In our own solar system, the effect of a large planet like Jupiter is to cause the Sun to move at about 12 m/s around their common centre of gravity. Even this is small, but astronomers have sophisticated spectrographs to observe the effect of such small speeds.

At the end of meeting all these challenges, Michael Mayor and Didier Queloz identified for the first time in 1995 that they have discovered "an exoplanet orbiting a solar type star". They used numerous new technologies, like optical fibers that could carry the star light to the spectrograph without distortions, better digital image sensor, increased light sensitivity etc. This discovery was immediately confirmed by other groups of astronomers. Just a few months later two more exoplanets were found. Now we know of several hundreds of new planets and planetary systems discovered by not only telescopes on earth but also space bound telescopes. New methods are being devised which are better than the radial velocity method.

Now that we know there are exoplanets, or probably even exo-solar systems, is there life out there in space? What do you think?

●



Can I really see an eclipse of the Sun?

N.D. Hari Dass and Kamal Lodaya

What is an eclipse?

An eclipse stands for blocking of light. In a cinema, when a person blocks light from the projector, he "eclipses" the screen and the film being shown on it. The Earth eclipses the Moon in the same way in a lunar eclipse.

With a coin, you can block the Sun's light from falling on your eye. For your eyes, the Sun is "eclipsed". The Moon eclipses the Sun like this to show us a solar eclipse.

Are eclipses related to phases of the Moon?

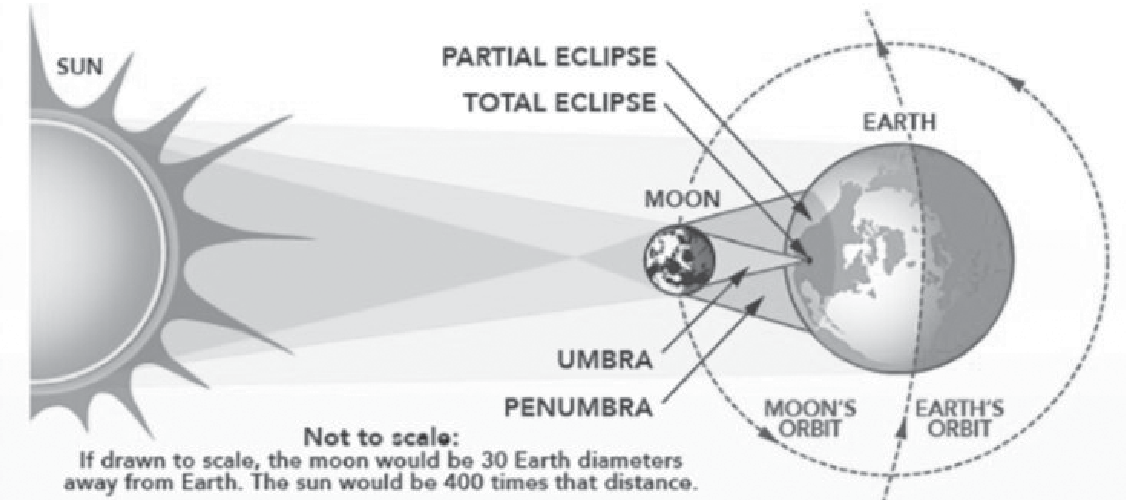
No. Phases of the Moon are a view of the sunlit portion of the Moon, seen from different angles as the Moon goes around the Earth. The picture shows how.

But eclipses require that the Sun, Moon and Earth be in a straight line (so that the shadow of one can fall on the other). Hence they can only happen on New Moon (*amavasya*) or Full Moon (*poornima*). Since December 26, 2019, is an *amavasya*, the Moon can come between the Sun and the Earth on that day. Its shadow falls on the Earth, giving us a solar eclipse.

Why don't eclipses happen every New and Full Moon?

The plane of the Moon's path around the Earth is tilted at an angle of 5 degrees to that of the Earth's path around the Sun, as shown in the figure. So on most New and Full Moons, the Sun, Earth and Moon are not in a straight line.

What are partial, annular and total eclipses?



Because the Moon's path is at an angle, only part of it may fall in the Earth's shadow. This gives rise to a partial lunar eclipse.

For a solar eclipse to be partial, there is an additional reason. The Moon's shadow on Earth is very small. So a central solar eclipse will be partial when seen from most places, and central only on a narrow path.

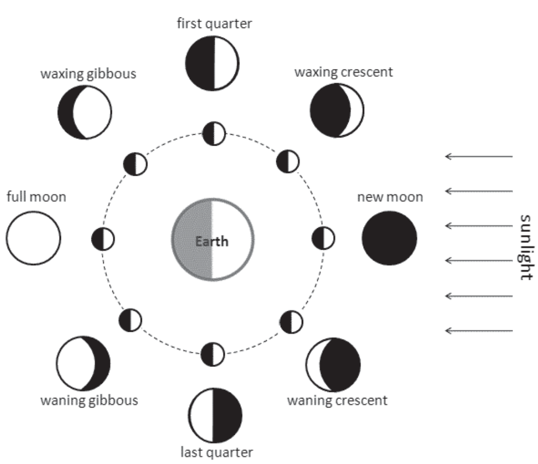
Eclipses are classified as:

. Partial when the Moon only partially obstructs the Sun, and

. Central when the Moon maximally obstructs the Sun,

. Total when the Moon completely obstructs the Sun, and

. Annular when a thin ring of the Sun's disc is not covered by the Moon.

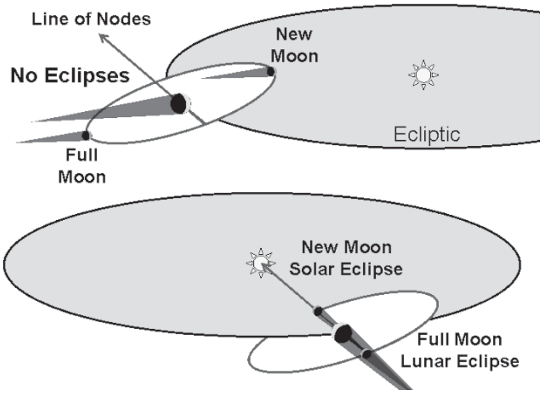


Why do we have an annular eclipse?

Due to the variation in the Earth-Moon distance, the angular diameter of the Moon and the Sun need not match exactly during a central solar eclipse. Because of this, when the Moon is farther enough from the Earth we get an annular eclipse. When the Moon is close enough to the Earth we get a total eclipse.

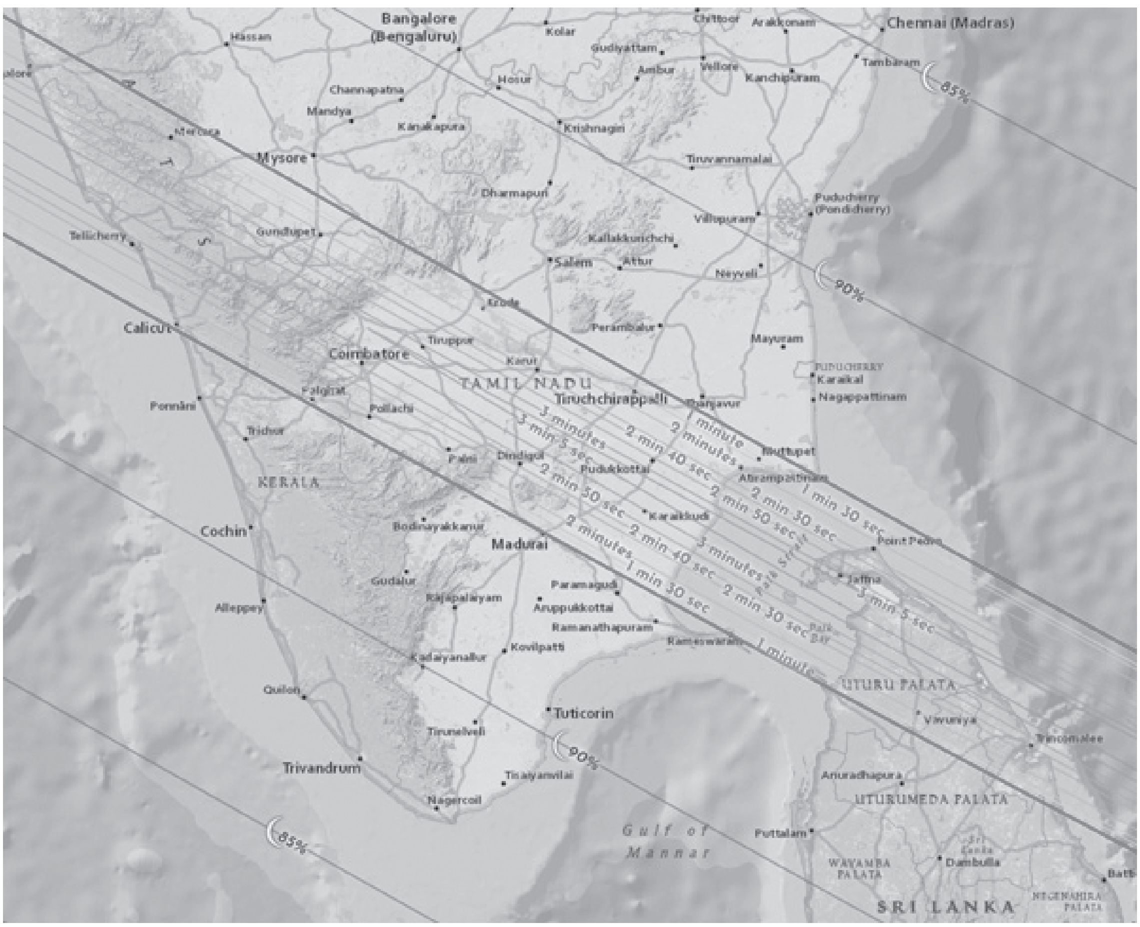
What will happen in the December eclipse?

The next central solar eclipse visible from India will be on the day after Christmas, 26 December 2019. All of India will see at least a partial eclipse. Less than half the solar surface will be covered in Kolkata, about three quarters in Hyderabad and 85% in Chennai. Partial eclipse will begin after 8 am and last beyond 11 am. Maximum eclipse will be between 9:24 am and 9:34 am for South



India. The figure shows, on both sides of the annularity path, obscuration belts of 90%, 75% and 50%.

Annularity will occur in India between 9:24 am to 9:34 am. The path of annularity will stretch from Mangalore at 13 degrees north latitude, through Kasaragod, Kannur, Kalpetta and Palakkad in Kerala, Madikere and Gundlupete in Karnataka, Ootacamund, Coimbatore, Tiruppur, Palani, Pollachi, Erode, Tiruchi, Karur, Dindigul, Pudukkottai and Karaikkudi in Tamil Nadu at 9 degrees north latitude, before moving on to Sri Lanka. The northern parts of Madurai city and




"Pin-hole" camera effect

Rameswaram island will have annularity for half a minute.

What is there to see during an eclipse?

It is interesting to monitor the progress of the eclipse itself. Another interesting phenomenon to observe during partial phase is the "Pin-hole" camera effect created by the leaves of trees as sunlight filters through them (more precisely, through gaps in them). Before the eclipse begins, the ground is covered by overlapping discs which are actually the images of the sun. As the eclipse progresses, these discs take the shape of the eclipsed sun. When the eclipse is quite advanced, one sees a myriad collection of crescents! The effect may be enhanced by spreading a white sheet on the ground.

Partial phases can also be observed by projecting the image of the Sun using the pin-hole idea. The following simple arrangement should work quite well: cover a plane mirror with a piece of paper having a circular hole of diameter 1 to 2 cm. The sunlight reflected from this arrangement may be thrown on to a shaded wall indoors. Reduction in the diameter of the hole in the paper will increase the sharpness of the image at the loss of its brightness.

Can I directly see the Sun during an eclipse?

Looking at the Sun, either directly or through the view-finder on your camera, can burn your eyes and cause blindness. Never look at the sun without adequate protection. This will also increase eye comfort by reducing the intensity of sun's visible rays.

The intensity of sunlight for direct safe viewing should be reduced by at least 100,000 times and ultra-violet and infra-red part of the solar radiation should be effectively cut off. Therefore always use a filter that will absorb equally and sufficiently the ultra-violet, infra-red and visible energy of the Sun.

There have been erroneous recommendations suggesting the use of materials that absorb the visible energy but do not absorb the dangerous, invisible infra-red rays.

These filters are NOT safe:

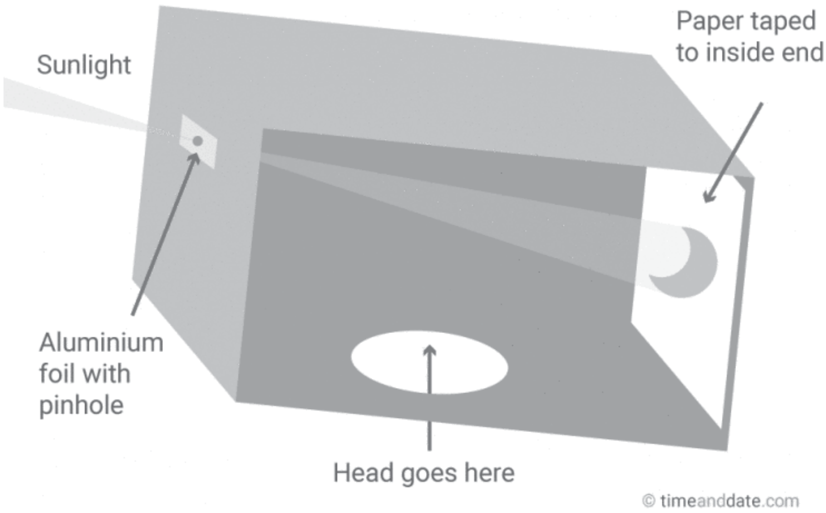
Smoked Glass, Crossed-Polarising elements, Colour film, Sunglasses.

These filters ARE safe:

Dark arc-welders glass, Two or three thicknesses of BLACK and WHITE (NOT colour) photographic film completely exposed and developed.

Place the filter in FRONT of your eyes before facing the sun.

Pinhole camera



Is this dangerous radiation more during an eclipse?

No. Protecting your eyes adequately means reducing exposure to ultra-violet and infra-red radiation, which is always coming from the Sun. But when you cut off visible light with a filter, you can see that it is not coming through. Since UV and IR radiation is invisible, if your filter does not cut it off, you can damage your eyes without your immediately being aware of it.

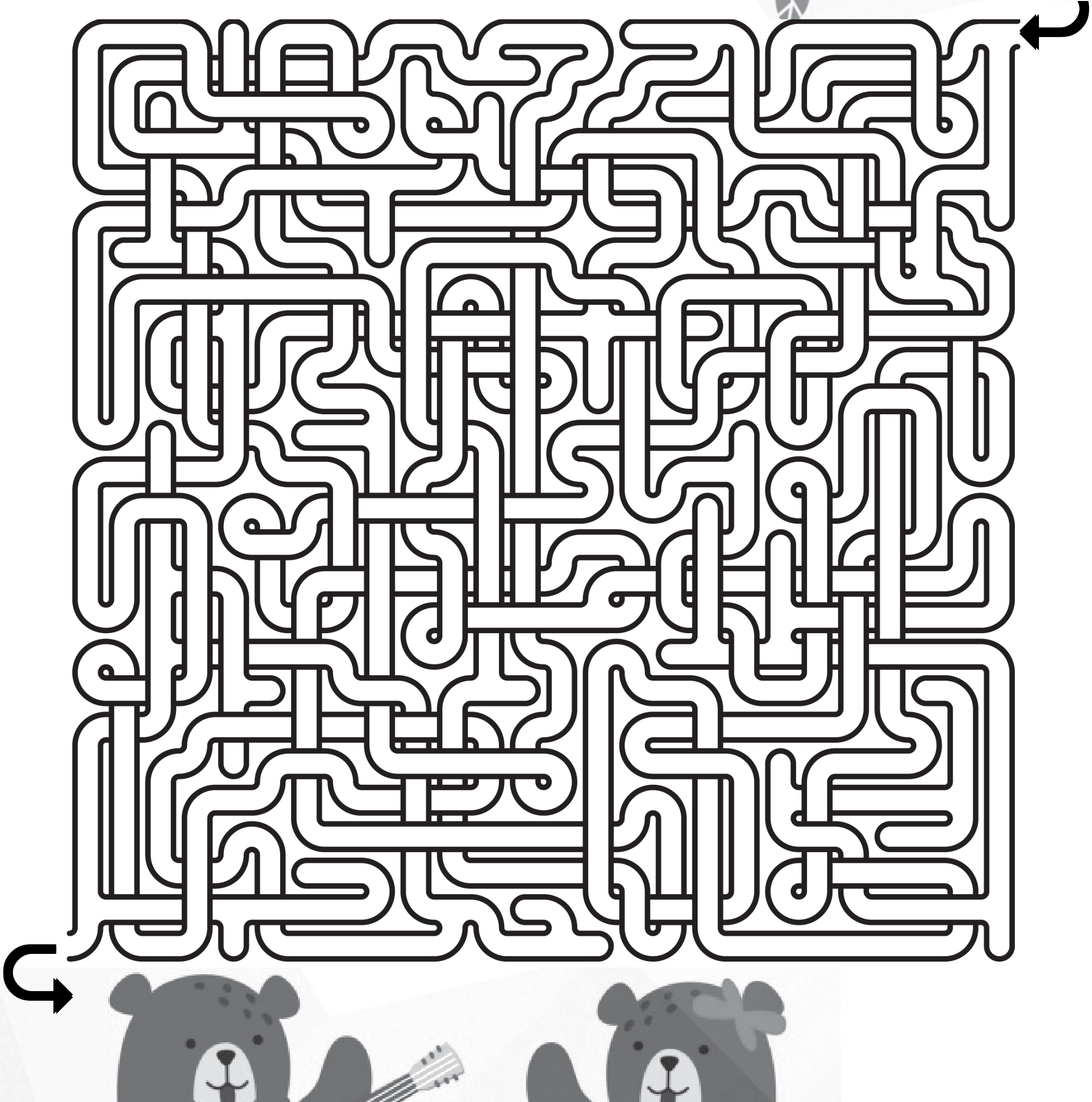
Can I photograph the eclipse with my camera? Since one should NEVER look at the Sun through a camera finder without suitable filters, it is best to aim the camera without using its finder. Filters cannot be rigidly mounted on to mobile cameras, at least not very easily.

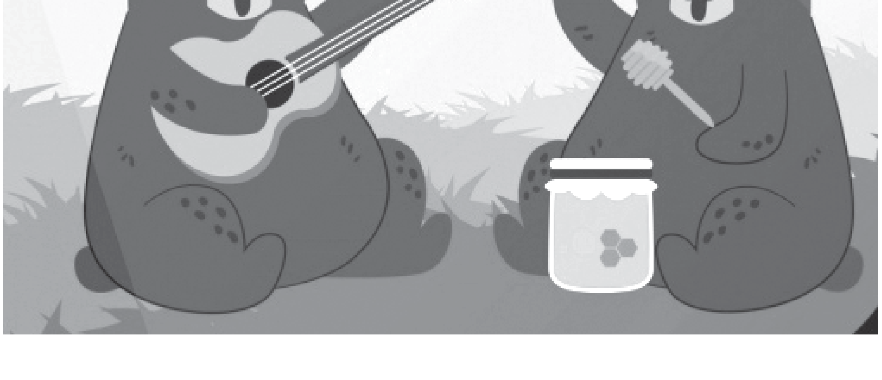
mobile phone camera

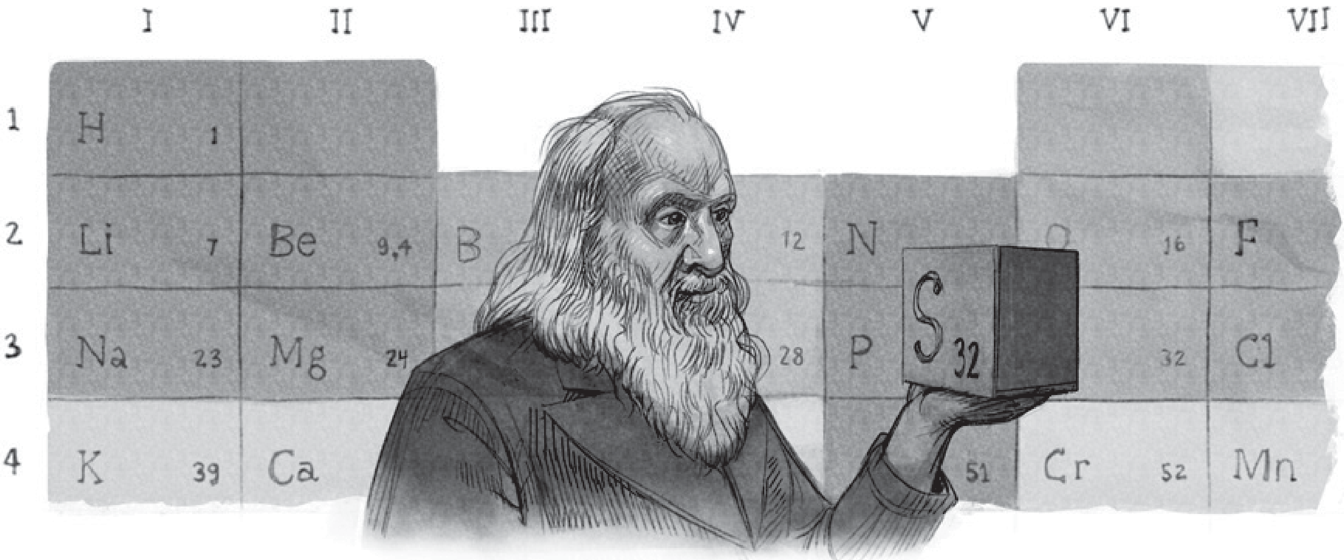
One way is to stick suitable filters to cover the camera openings with the help of scotch tapes. It is not advisable to simply hold goggles over the camera openings. Even after fixing filters over camera openings, the danger is that one may inadvertently look up at the sun directly, which should be avoided at all costs.

Another ingenious idea is to have the Sun behind you so the danger of even accidentally looking at the Sun directly does not arise. Most mobile phones come with front facing and back facing cameras. Choose the camera that faces your face and scenes behind your back.Now cover that camera opening with a layer of suitable filter. Now you can look at the screen of the camera without looking directly at the Sun.

Show the way!

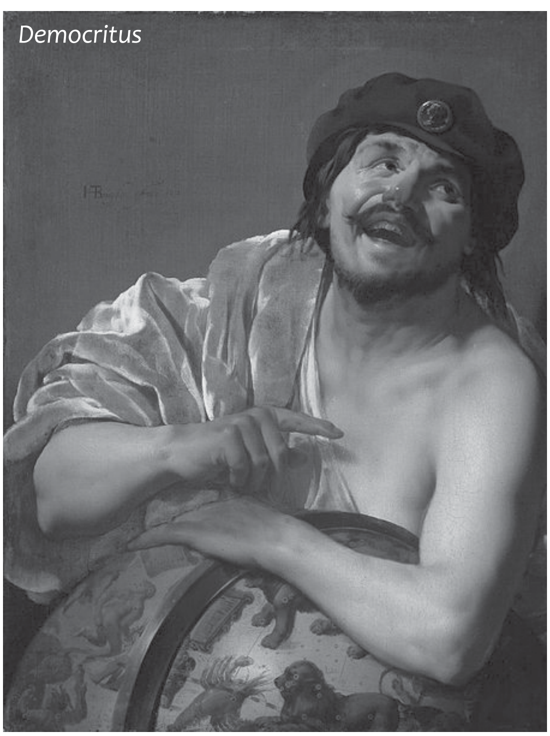






Dmitry Mendeleev: Playing cards with atoms

M.V.N. Murthy,
The Institute of Mathematical Sciences, Chennai


Democritus

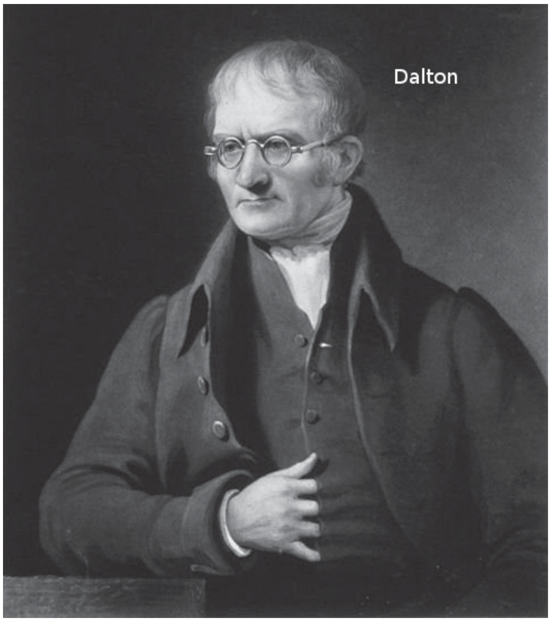
The **year** 2019 marks the 150th anniversary of the development of the **Periodic** Law of the Elements independently by Dmitri Mendeleev and Lothar Meyer. To celebrate this, we are reprinting an article on Mendeleev that appeared in two parts in Nov 2012 and Jan 2013 respectively.

The laughing philosopher

Our story of Mendeleev has to begin with Democritus, born in Abdera in Greece some time around 460 BC. He was popularly known as the l*aughing philosopher* since he was a fun loving guy. He is supposed to have traveled widely including to far off places such as India and Egypt. He was not exactly popular with his famous contemporaries like **Plato** and **Aristotle** who seem to have disapproved of his ideas.

But he was more a scientist than a philosopher. He is supposed to have said "Nothing exists except *atoms* and *space* (or *void*); everything else is opinion". The name atom has its origins in the Greek word "*atomos*" (*a*=not+*tomos*=divisible, meaning indivisible) used by Democritus and revived in 1805 by British chemist **John Dalton**. (Shown is a 1628 painting of Democritus by **Hendrik ter Brugghen;** source: wikipedia).

Democritus held the view that everything is made up of atoms which are indivisible. He thought there may be many different types of atoms coming in a variety of shapes and sizes. But if we only have objects with indivisible atoms arranged together, you cannot break or



even cut such an object and further no motion is possible. In response to this criticism, Democritus introduced the idea of *void* or *space*, or vacuum in modern language, which allows the atoms to wiggle around to make motion possible.

The notion of vacuum is almost akin to introducing the concept of zero in the theory of numbers. It is really nothing, but its presence is necessary in order to make the connection between indivisible atoms and the structure of matter. The notion of space between atoms is as close as we can get to the modern notion of the structure of matter.

Democritus was ignored by by the dominant Greek philosophers like Plato and Aristotle. We know about Democritus' ideas only through quotations from later Greek historians. Nevertheless, the idea of the atom was put in cold storage for a very very long time for nearly 2000 years. Only recently was it revived by the physicists Galileo and later Sir Isaac Newton, in the 17th century. Later the chemists took over and refined the idea of the atom, leading to the periodic table of atoms.

Discovery of nothing

To prove Democritus' ideas you not only have to prove the existence of atoms but also show that there is empty space between them. The christian church all along insisted that nature abhors vacuum. This followed the ideas of Aristotle who opposed the idea of vacuum during the time of Democritus.

It was up to **Evangelista Toricelli**, a student of **Galileo Galilei**, to prove the that there can indeed be "nothing". He created a *vacuum* where the pressure was about a billionth of normal atmospheric pressure. Around the same time, Torricelli's experiments were put on a firm footing by **Robert Boyle**. Using mercury and air columns, he showed that increasing pressure reduces the volume in direct proportion. We call this the *Boyle's law*, it is one of the most important discoveries used by scientists extensively in analysing properties of gases.

While squeezing gas was possible, what about liquids and solids? No problem, since you assume there is much less of space or "nothing" in liquids and and even less in solids. Still, Boyle, who preferred to call the atoms *corpuscles*, had problems convincing his contemporaries in the 17th century who were still rooted in the Aristotelean universe of continuous matter.

Work of Lavoisier

There remains some thing more—what are these atoms? How many types are there? Democritus had only vague ideas about what types of atoms are there and how they combine. We need to do better. It was left to the chemists to complete this job.

Until the Frenchman **Antoine-Laurent de Lavoisier** came on the scene in the 18th century (1743-1794), chemistry was not yet a quantitative science. Various beliefs were in existence about the content of matter: people thought the fundamental elements were *air, earth, water, fire*. In ancient India, space was also added to this to make up five fundamental elements. It was a complex situation with no perceived order.

Lavoisier made accurate mass measurements of reactants and products in a chemical reaction and showed that even though the state of the matter may change in a chemical reaction, the total mass of the matter before and after every chemical change remains the same. He created the "chemical balance" which he used expertly in his work.

Lavoisier played with gases extensively; he was the first to split water into hydrogen and oxygen (found to be always in the ratio 2:1) and also produced water by mixing hydrogen and oxygen in the correct proportion of two parts of hydrogen with one part of oxygen. He also investigated the composition of air to prove that it was primarily a mixture of nitrogen and oxygen.

Antoine-Laurent de Lavoisier

Lavoisier also brought some order to the chaotic system of naming in chemistry during his time. He is remembered today for putting chemistry as a science on par with physics as an exact science in the 18th century.

Unfortunately Lavoisier's life was cut short when he was executed at the age of 50 during the "Reign of Terror in France". This was the period following the French revolution when many noblemen were branded as traitors and guillotined.

Nevertheless, Lavoisier did not think in terms of atoms. That was left to **John Dalton**, an Englishman, after whom followed various other scientists before Mendeleev finally completely solved the puzzle.

The grammar of atoms

John Dalton (1766-1844), an English school teacher, was considered an amateur among scientists. To the extent we know, he was the one to revive the word atom again after a long gap from Democritus. They were variously and vaguely called corpuscles, particles, elements, etc., by others including Newton.

Dalton's atomic theory as we call it today is based on the classification of chemical elements and determination of their weights by Lavoisier. It defines atoms and their properties as well as how different atoms interact.

Unlike Lavoisier he was not very careful with numbers. He got many right and also many wrong. He had the wrong relative weight between hydrogen and oxygen and therefore a wrong composition for water—he thought it was HO and not H_2O. Nevertheless, coming 2,200 years after Democritus, his was a profound discovery.

John Newlands and the law of octaves

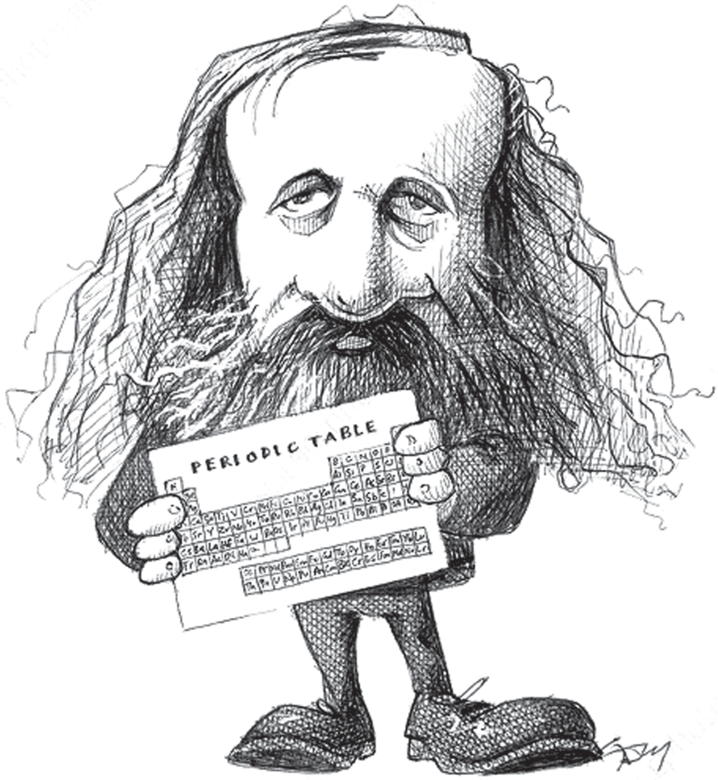
A similar table was also prepared by **Lother Meyer**, in Germany, with 28 elements, but he did not make any prediction about new elements. However, around the same time John Alexander Newlands, in England, also devised a periodic table based on the "law of octaves", also known as "Newlands Law".

He arranged all 56 elements known at that time into eleven groups. He noticed that many pairs of similar elements exist whose masses


Dmitri Mendeleev


Lother Meyer

differ by some multiples of eight. That is, an element will exhibit similar properties to the eighth element following it in the table. He likened this to the octaves of *musical scales*. He also alluded to the existence of as yet undiscovered elements like Germanium. Like Mendeleev he was also ignored and ridiculed by contemporaries and the society of chemists refused to accept his work for publication.



Journey's end

Finally we come to the end of the journey in the quest for atoms—namely to **Dmitri Mendeleev** (1834-1907)—the man who played cards with the atoms. Mendeleev was born in the Russian province of Siberia. Life was not easy for Mendeleev. He had tuberculosis during his early years, he survived on a diet of sour milk (sort of medical fad).

He first studied and then taught in the University of St. Petersburg until the University fired him for backing the students in a protest. Mendeleev was responsible for the periodic table of elements, a modern version of which may be found in every school chemistry laboratory. This revolutionised our understanding of the structure of matter. However, during his life he was subjected to a lot of derision for his periodic table by his colleagues and contemporaries.

Mendeleev started by ordering his atoms by their atomic weights. He apparently enjoyed playing the game of patience, a kind of card game. He did so with atoms as well. He wrote each one of them on cards listing the symbol, atomic weight and properties. Around 1863 about 56 elements were known and many more were being added at approximately one every year at this time. He arranged these cards in increasing order of their atomic weight. In doing so he discovered an important periodic property.

He found that the chemical properties of the atoms appeared to repeat after every eight cards—for example the properties of hydrogen (1), florine (9), and chlorine (17) are similar being active gases. Similarly lithium (3), sodium

(11) and potassium (19) were all found to be active metals. (Mendeleev put hydrogen together with flourine and chlorine. It is now understood that it is different from them since the latter are what are called electron acceptors.)

Fill in the blanks!

So Mendeleev started making a table with eight columns. Elements with similar properties were arranged in a column. So below lithium came sodium, potassium, etc. It was not perfect, but he was on the right track. The grid of elements so formed had many empty slots. Mendeleev did something that is revolutionary—he gave names to these blanks even though the element was not known in his time! The blank below aluminium was called *eka-aluminium*, the blank below silicon and boron were called *eka-silicon* and *eka-boron*. These were discovered later and given the names gallium (eka-aluminium), germanium (eka-silicon) and scandium (eka-boron) about ten years after he predicted them. The elements that were known and ordered in 1871 is shown in the figure.

Sometimes there were two missing slots, not just one. For the blank below *eka-* he used the prefix *dvi-* and below that he called it *tri-*. He predicted the existence of eight such elements. The Sanskrit sounding prefixes that he used, eka-,dvi-,tri-, (these are to be pronounces as eka, dvee, tree) meaning 1,2,3, has a nice history. In using these names Mendeleev was actually showing his appreciation of Sanskrit grammarians of ancient India whose works inspired his periodic table in the first place.

Mendeleev died in 1907 in Saint Petersburg. He was never fully appreciated by his contemporaries. He was never awarded the Nobel prize though he was nominated twice. He however received the ultimate honour for a teacher—his students followed the funeral procession upon his death holding aloft the periodic table, the chart that adorns every chemistry class room. Now we have a a crater on the Moon named after him. Element number 101 is named after him, *mendelevium*.

The periodic table today

The modern periodic table has grown since Mendeleev's time. Now we have 118 elements arranged in a more modern way though the basic idea of Mendeleev pervades the arrangement. All matter was made up of indivisible atoms. As long as only chemical reactions are involved this is indeed the end of the story.

The discovery of electron and nucleus in the beginning of 20th century started yet another inward-bound journey. The understanding of the structure of the nucleus required new types of interactions. A new periodic table of particles, the so-called **standard model**, was discovered. In fact the last piece of the new periodic table, namely the Higgs boson, has just been discovered after almost exactly 100 years after the discovery of the nucleus by Rutherford.

Acknowledgement: This article is partly inspired by the beautiful book "The God Particle—If the universe is the answer what is the question?" by **Leon Lederman** along with biographical accounts of various people as given in Wikipedia.

●

Tasty Flowers

Archana Ghode

A lot of flowers smell wonderful, but did you know that some of them taste good too? They can be used as ingredients in culinary dishes as well as herbal medicine, particularly dried flowers.

Let's start with our national flower, the lotus.

Lotus

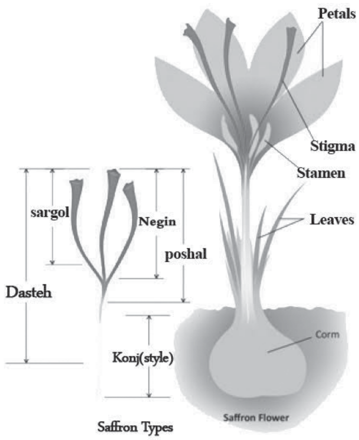
In China, the lotus flower is considered a delicacy. The Chinese dip the flower in a mixture of eggs and flour, deep fry them and sprinkle them with sugar. This crispy dish is considered to contribute to longevity. In India we use the stem (kamalkakari), seed (makhana) and root nodule (singhara) in many varieties of dishes.

Papaya

Papaya flowers are rich in antioxidants and vitamins A, C and E. The flower has several health benefits including lowering cholesterol, improving appetite and controlling diabetes. The tender white flowers are slightly bitter to taste but can be squeezed with salt and be used as a tasty side dish.

Banana

Banana flowers are large, pear-shaped and purplish in colour. In India, they are mainly used in South Indian and Bengali cuisine. In Thailand and in other south East Asian countries, banana flowers are commonly



used, either in their cooked or raw forms, with spicy dips.

Banana flowers are rich in protein, potassium, calcium, copper, phosphorus, iron, magnesium and Vitamin E.

Saffron

The stigmas (female portion) of the saffron flower are among the most expensive spices in the world.

The flower is purple in colour while the strands of saffron are reddish-orange.

The plant flowers in autumn and grows in a number of places including Greece, India (Kashmir), Spain, Egypt, Morocco and Turkey. It is considered a medicine for throat irritation.

Saffron is used in varieties of dishes such as pulaos, curries, phirni (rice pudding) and kulfis (a frozen dairy dessert). Kahwa, a traditional drink of Kashmir, is made up of nuts and spices including saffron.

Tea Infusions

Traditional flowers like jasmine, hibiscus and chamomile are usually mixed in green tea but sometimes black or white tea is used instead. They provide many powerful health benefits.

Drumstick

Drumstick (Moringa), pumpkin and Sesbania (Agathi) flowers are factories of nutrients. They are added to vegetable dishes and are also used in making cutlets, bhajjis and vadas.

Do You Know?

1. Why does Venus rotate “backwards”?
2. We forget so many things that we learn, but we never forget how to ride a bicycle. Why is this?
3. Smells seem to vanish after some time. Where do smells go?
4. Why are lemons yellow and limes green?
5. Some day we will be able to upload our brains to computers, what will then happen to our idea of self?

Answers to last issue’s Do You Know?

1. Do radioactive things glow in the dark?

Ans: The short answer to your question is “no,” radioactive things do not glow in the dark, not by themselves. Radiation emitted by radioactive materials is not visible to the human eye.

But then, why do so many people think of glowing things when they think of radioactive materials? This is because we are used to “radium dials” on watches and clocks, that make the dial visible in the dark, and we know that radium is radioactive.

Even if radition is invisible, there are ways to “convert” this invisible energy to visible light.

Many substances emit visible light if “stimulated” by the ionizing radiation from radioactive material. These materials are known as “fluors” or “scintilators.” So, by mixing some radioactive material with such a fluor, you can make a substance that glows. This is the kind of material used in the radium dials on clocks and instruments on ships and airplanes to make them visible in the dark.

It is also possible to “trick” radioactive material into creating visible light. This is called Cherenkov radiation. This happens when the radiation from the radioactive material goes into a material such as glass or water. Because the speed of light in this material is relatively slow (compared to the maximum speed of light in a vacuum), the radiation is actually traveling faster than light can travel in that material, and so it gives off light as it slows down. But to actually see this glow, it usually takes something which is very radioactive, such as the internal parts of a nuclear reactor. Weak Cherenkov light can also be made from smaller amounts of radioactivity, but very sensitive devices have to be used to detect it.

2. Is vacuum matter, or a state of matter?

Ans: We all think of vaccum as space with no matter in it. A partial vacuum is a vacuum with low amounts of matter enclosed. A total, perfect, or absolute vacuum has no matter enclosed. Sometimes this type of vacuum is referred to as “free space.” But it is hard to imagine such an empty spatial area. How do we even find absence of matter in the universe?

In the laboratory, since it is really hard to get all the matter out of any space, it is defined in an experimental way: vaccum us space in which the pressure is so low that any particles in the space do not affect any processes being carried on there. Thus it is defined by an experimental limit, called the “ultrahigh vacuum” (UHV). The UHV is obtained when reaching the low pressure 10^-7 Pascal. This space is created with vacuum pumps, but this vacuum is still filled with millions of particles per cubic millimeter. Even in deep space between the stars, which we consider “empty”, the vacuum contains millions of particles per cubic metre.

Even though it seems an abstract concept, vacuum is very important and useful in everyday life and in technology. Your lungs take in air when your diaphragm drops, creating a partial vacuum in the alveoli of the lungs, causing air to rush in. A vacuum cleaner sucks up debris because it creates a pressure difference between the area to be cleaned and the suction tube. Vacuum tubes are devices, usually made of glass, that contain very low gas pressures inside the tube.

Many modern devices (like the integrated circuit chips that make everything from cars to computers work), have to be fabricated in a vacuum. In many science laboratoties, equipment only work at extremely cold temperatures, that need a vacuum.

3. If you jumped into a pool of liquid oxygen, would your body instantly crystallize?

Ans: It will of course be immensely cold and lead to death, but nothing happens instantly. The first thing would be frostbite to the skin followed by the onset of hypothermia to the internal organs. No doubt everything would “freeze up” with time.

What this really brings up is safety issues with cryogenic fluids, that is, those substances that are normally gases (like oxygen, nitrogen, carbon dioxide, hydrogen, or helium) at room temperature but can be changed to liquid form through the use of very low temperatures. When you have them in liquid form we do need to be extremely careful.

Besides the usual danger of handling

anything that cold, there is something much more dangerous with these liquids. If they are exposed to the much warmer conditions in which we live, they will convert very quickly back into gas form. Then they will expand out to hundreds of times their liquid volume. In some situations, this can mean that the air (and oxygen) around you will be displaced by this gas. If it contains no oxygen then you may end up breathing an atmosphere almost devoid of any oxygen. The worst thing about this is that you will NOT realize that you are not breathing proper air and you will pass out within seconds. Extreme injury and death can result all too quickly.

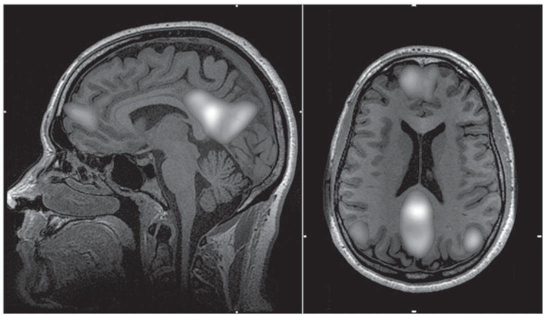
In the case of oxygen, you have another danger. If the liquid oxygen is converting back into a gas, then you will have too much oxygen around you. Oxygen is what is needed to keep a fire burning. So with extra oxygen around, substances that are normally almost non-flammable can suddenly be very flammable!

So don't worry too much about jumping into liquid oxygen, but do worry about handling any liquid oxygen with great care.

4. What is the brain doing when we are at rest?

Ans: What do you mean by "we"? Don't you include your brain in you? So the question already suggests that the brain is active when resting as a person.

The important thing to realise is that taking rest is not being inactive, but engaging in "restorative" activity. It is not a completely passive state. In fact, different people consider different activities as restorative. Some even claim long walks to be relaxing.



Some climb mountains on vacation. Such activities might be vigorous but yet restorative becase they offer a complete break from "normal" working life.

The critical thing to recognize is that when we are letting our minds wander, when our minds do not have any particular thing they have to focus on, our brains are quite active. When you do things like go for a long walk, your subconscious mind keeps working on problems. The experience of having the mind slightly relaxed allows it to explore different combinations of ideas, to test out different solutions. Once it has arrived at one that looks promising, you might have an "Aha" moment of realisation.

The work of Marcus Rachle, a celebrated neuroscientist, showed something very special in 2014 (for which he was awarded the prestigious Kavli prize in 2015). His team studied the brains of persons taking rest quietly without falling asleep. They found a unique fronto-parietal network in the brain. It has come to be known as the "default mode network", whose regions are more active during rest than during physically active states. They also studied chemical receptors in the brain and showed that the brain could actually use more energy during these default modes than in attention demanding tasks!

So the correct answer is that the brain is certainly working (in many senses of the term) when we are resting, and science is only now beginning to understand what it is doing.

5. Why do we swing our arms when we walk?

Ans: One way of asking this question is to wonder whether it is *natural* to swing your arms when you walk, because if it is natural, there is probably some reason for it. Well, try walking without moving your arms. Better yet, try walking while swinging your left arm when you step with your left foot and vice versa. Both of these practices are unlike the natural method of arm swinging while walking, which is for your left arm to swing forward as you step forward with your right foot.

Experts believe that the ancestors of modern humans began walking upright at least 3.6 million years ago. Yet the reason we move our arms out of synchronization with our legs has only recently been solved.

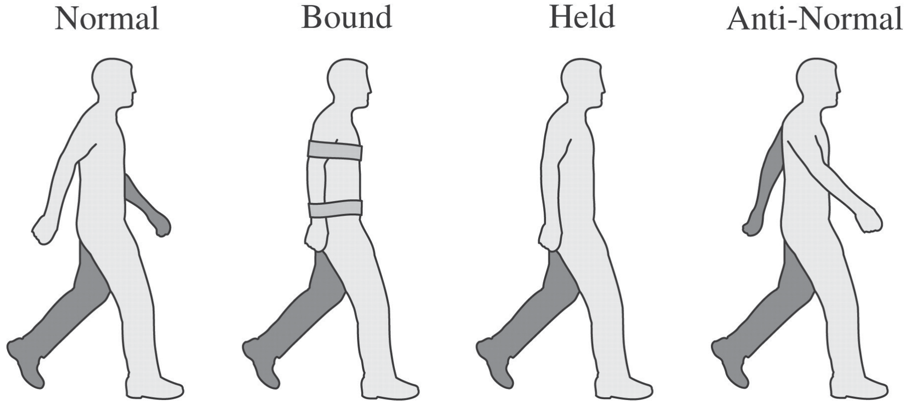
For years, the answer was thought to be simply balance. Research published in 2010 by a team led by Dr Sjoerd Bruijn in the Netherlands confirmed this, but with a twist. Swinging our arms does not make us much more stable when walking normally. But it does help *restore* our balance if we suddenly lose our footing while walking over uneven ground.

His group also found another benefit: swinging our arms while walking is more energy efficient than keeping them still. The found that people who hold their arms still while walking use 12% more energy than people who swing their arms normally. Even more surprisingly, they found that when they had people walk with their arms synchronized with their legs (left arm swing forward when stepping forward with the left leg), those people used 26% more energy compared to normal walking.

Normal arm swinging actually does not use much energy from the arm muscles. Simply walking causes the body to sway in a way that makes the arms move naturally, like a pendulum. While it does take energy to move our arms, this is more than compensated for by the reduced energy needed by the rest of the body to propel itself forward.

When you walk, your arms begin to swing naturally without much effort from your arm muscles. The natural movement of your arms also helps to offset a part of the force caused by your legs hitting the ground, keeping your torso and hips from wobbling and twisting too much. This results in your legs using less energy!

Sources: Jefferson Labs, Science focus, Scientific American



SCIENCE NEWS

Headlines

- Making clay work as a natural pesticide
- How mammals flourished after dinosaur extinction
- Breeding has given different dogs distinct brain shapes
- Frozen science

● Making clay work as a natural pesticide

Pests are a big problem for farmers, as one swarm of pests can destroy a whole field of crops. *Pesticides* are used by farmers to kill them. But chemical pesticides cause other problems. They contain high levels of toxicity, and cause risks to human and environmental health. Despite these concerns, pesticides are perceived as necessary and are used.

One big question is to find alternatives to chemical pesticides, and in India, natural bio-pesticides are often suggested. Now **Anna Mathis**, a high school student from the USA, has demonstrated that *kaolin*, a natural clay mineral could offer an easily accessible, cost-efficient, and organic alternative. Kaolin is non-toxic, natural, and harmless to humans or animals.

In order to test her hypothesis, Anna obtained micro-filtered and raw kaolin slurries

from a company, then applied them to vegetable plants. When combined with water, the kaolin became a liquid that Anna sprayed directly onto the plants.

The micro-filtered and raw kaolin slurries were taken from different mining locations. Anna used two different kaolin filtrations: a fine particle clay and a coarse particle clay. The main difference between the two was the presence of iron in the raw clay, while the micro-filtered slurry was pure kaolin.

For six weeks, Anna exposed the kaolin-covered plants to common pests, such as aphids, beetles, and caterpillars. After six weeks, she analyzed the pest damage on the plants and found that the micro-filtered kaolin (from fine clay) was the more effective of the two, and could be of potential use as a natural pesticide.

When sprayed onto plants, the kaolin forms a thin film that acts as a barrier to insects. Chemical pesticides are applied after the farmer spots plant damage, while kaolin may deter pests from eating plants beforehand.

This work got Anna a **Community Innovation in Science** award. She was among the 28 students (from all over the world) who got this award last year. Using the positive results and knowledge gained from her studies, Anna is currently doing research to formulate a natural kaolin pesticide, to prevent insect damage to plants in a safe and healthy way.

This is the spirit of science, and school students can scientifically study the resources in their own community and attempt to solve its problems.

● How mammals flourished after dinosaur extinction

We all have read that some 66 million years ago, an asteroid wiped out up to 75 percent of Earth's species. This event is believed to have marked the end of the dinosaurs, but certainly not all life died. Understanding how those survivors fared has been hard. After all, few fossils exist from right after the cataclysm. But one unexpected treasure trove has now turned up in the **Denver Basin** in Colorado, USA. These fossils offer scientists a glimpse into how mammals, plants and reptiles ultimately came to flourish. Study of these fossils suggest that mammals took over from the dinosaurs.

The Corral Bluffs site in the Denver Basin is the only known locality in the world to have numerous fossils of animals and plants representing a whole series of time slices in the 1 million years following the Cretaceous–Paleogene extinction. Over the last three years, a team of researchers has uncovered more than 7000 fossils there. These include 233 kinds of plants and 16 species of mammals, among which are the earliest known mammals to reach relatively large sizes as they evolved and filled ecological

roles previously occupied by dinosaurs. They found that within 700,000 years, some mammals had grown to be 100 times as big as the original survivors. Their research was reported in the October issue of the magazine "Science".

By comparing plant and animal fossils with data on precise dates for rocks, the researchers puzzled together what happened. Ferns and palms quickly came to dominate. Slowly, forests with a much greater diversity of trees replaced them.

Mammals took a little while to recover. But in time they swiftly diversified into a variety of forms and sizes. About the size of a rat, the biggest initial survivors of the impact weighed just 500 grams. But rock from 100,000 years later hosts fossils of raccoon-sized mammals that would have weighed up to 6 kilograms. That weight is apparently not far from some of the biggest mammals that existed before the mass extinction.

By 300,000 years after the impact, some mammals were now 25 to 30 kilograms. This included the beaver-sized *Carsioptychus*. What led to that growth in their size? A lack of large predators in the post-impact world have helped. So would an explosion in plant diversity, which would have given them a wider array of food choices. By 700,000 years after the mass extinction, these rock deposits held fossils of the earliest known members of the *legume*, or bean, family. Mammals also appeared weighing nearly 50 kilograms, such as the wolf-size *Eoconodon*.

The sheer number of fossils and different time slices revealed at Corral Bluffs is astonishing. So also is the number of mammal skulls, at least 40 so far. Skulls are usually very rare.

Many mammals before the impact were very different from those today. For instance, so-called "placental" mammals came to dominate later. These are animals whose young develops in a womb. Today, they account for some 95 percent of the roughly 6,500 mammal species alive.

Evidence of fossils from another site (in New Mexico) confirms this acceleration of mammals.

● **Breeding has given different dogs distinct brain shapes**

For centuries, dog breeders have been experimenting on producing breeds, shaping the way dogs look and behave. It is now becoming clear that meddling in doggy evolution has interfered with the pups' brains, too.

A recent issue of the *Journal of Neuroscience* reports on a study of brain evolution, in which a team of researchers scanned the brains of 62 pure-bred dogs representing 33 breeds. They used MRI, or magnetic resonance imaging, to map the shapes of brain structures. Their results show that dog brains are not all alike. The shapes

of various brain regions can differ broadly by the breed.

The distinct brain shapes were not simply due to the breed's different head shapes, scientists found. Nor were differences due to the size of the dogs' brains or bodies. Instead, they found that humans' selective breeding of their dogs have shaped the animals' brains, bit by bit.

They found more. Some parts of the brain varied more than others. Smell and taste regions, for instance, varied a lot between breeds. Those areas may support specialized behaviours that often serve people. Such behaviours include hunting by smell, guarding and providing companionship.

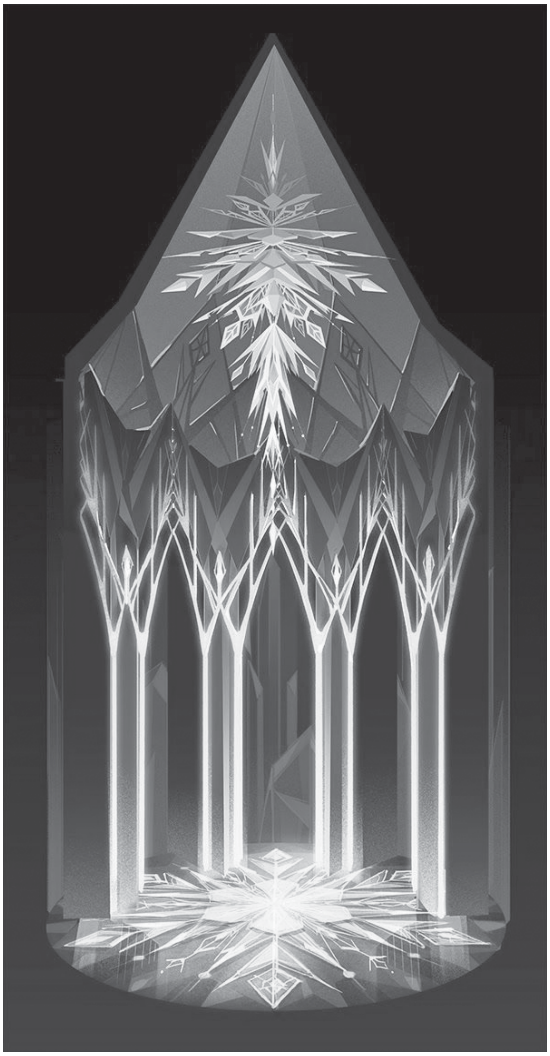
- **Frozen science**

The film *Frozen* was very popular when it released some years ago, and now a sequel has come out. In these films, the ice queen Elsa has a magical command over snow and ice. Snowflakes sprinkle from her fingertips. She can blast ice to fight flames. But how closely does Elsa's icy touch approach reality? Can scientists do what Elsa can?

In fact, scientists *can* concoct snowflakes. Architects can also make fantastical structures from ice. Indeed, *Disney* used **Professor Kenneth Libbrecht**, a physicist and snowflake expert at California Institute of Technology as a consultant for *Frozen*.

As ice crystals, snowflakes form only when it is freezing. Elaborate branching patterns form around –15 degrees Celsius. When humidity is high, the air contains a lot of water vapour. High humidity makes conditions ripe for snow. But to kick off the process, snowflakes need a process called nucleation. That means bringing water vapour molecules together to form droplets, usually by condensing onto a particle of dust or something else. Then they freeze and grow. It takes about 100,000 cloud droplets to make one snowflake.

In the laboratory, scientists can spur the formation of snowflakes in several ways. For instance, they can let compressed air out of a container. Parts of the air in that expanding gas go to really low temperatures, like –40 to –60 degrees C. At those temperatures, fewer molecules need to unite to start a snowflake. Dry ice, popping bubble wrap and even bolts of electricity can do the trick.



The big advantage Elsa has in the movie is that her fingertips kick off snowflake growth. She is also much faster than nature. Snowflakes take some 15 minutes to an hour to grow in the laboratory. Snowflakes tumbling through the clouds take a similar amount of time.

Elsa builds an ice castle in the movie *Frozen*, which also has a time issue. In the space of around three minutes, while Elsa belts out the song “Let It Go”, her palace stretches to the sky. How can one do it? By removing heat from a lot of water in the air fast enough to freeze it like this. Unfortunately, not only is such speed difficult, there is simply not that much water in the air.

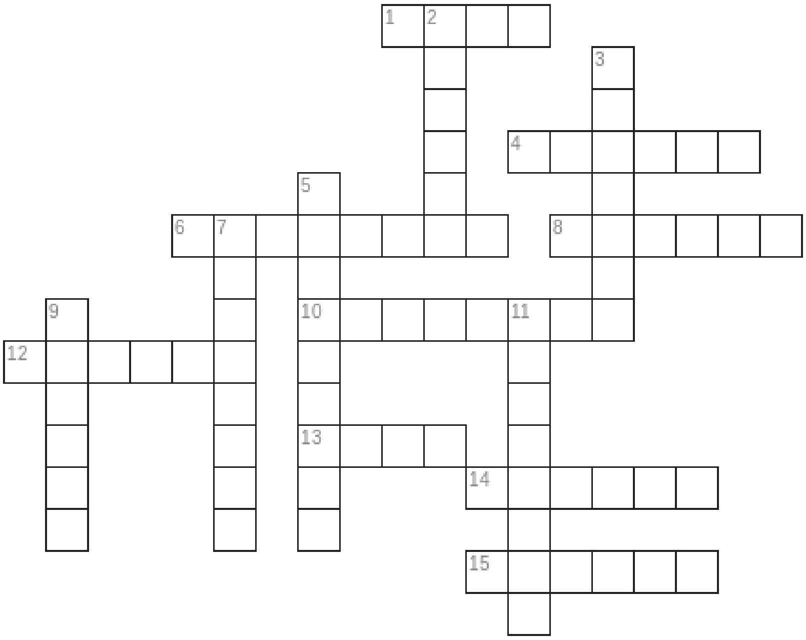
But if we manage to build it, how does the ice castle hold up? Obviously, ice melts when it is warm. Melting aside, the palace still might not be all that solid. Ice is brittle. A sheet of it shatters when hit by a hammer. Under pressure too, ice can crack and shatter. Even below freezing, ice softens as it warms. It also can deform under pressure. This is what happens with glaciers. Ice at the bottom will eventually deform under a glacier’s weight. This is called “creep” and is the main reason that glaciers flow (they creep along, so to speak).

Something like this could happen to Elsa’s ice palace, especially if it is tall and heavy. With soft and creeping ice at its base, the entire building would start shifting and leaning and cracking apart.

Elsa could strengthen her castle by adding a second material like cellulose. In fact some scientists at NASA are working on how what to build an ice habitat on Mars for human explorers. Ice walls might even help protect astronauts, because ice can block radiation. They are trying all this because ice is already found on Mars.

Perhaps Elsa could help NASA with freezing ice for the Mars habitat. She would probably be at home there, since the cold does not bother her anyway!

Sources: Scientific American, Science News, Student society for science



Periodic Table Crossword

Across

1 A yellow precious metal, the chemical element of atomic number 79.

4 A precious shiny grayish-white metal, the chemical element of atomic number 47.

6 The chemical element of atomic number 17. Think of swimming pools.

8 A silvery-white metal, the chemical element of atomic number 28.

10 The chemical element of atomic number 13. It can be in the form of foil.

12 A red-brown metal, the chemical element of atomic number 29.

13 A strong, hard magnetic silvery-gray metal.

14 The chemical element of atomic number 27, a hard silvery-white magnetic metal.

15 The chemical element of atomic number 2. Think of balloons

Down

2 The air you breathe.

3 The chemical element of atomic number 20, a soft gray metal.

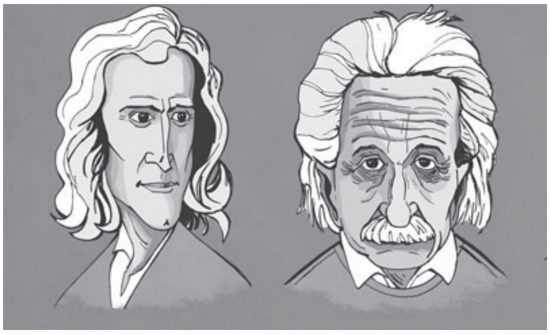
5 The chemical element of atomic number 19. Think of bananas

7 A colorless, odorless, highly flammable gas.

9 The chemical element of atomic number 11. Think of table salt.

11 A colorless, odorless unreactive gas that forms about 78 percent of the earth's atmosphere.

From: http://www.whenwecrosswords.com/crossword/



Jest for Fun

Newton or Pascal?

All the great scientists met up in heaven after they had died and decided to play a game of hide and seek.

Einstein was the one who had the den. He counted up to one hundred before he started to search for the other scientists.

Everyone started to hide except Newton who just drew a square with sides of one metre and stood in it, right in front of Einstein.

Einsteins finished counting ....97, 98, 99, 100! He opened his eyes and found Newton standing right in front of him.

Einstein exclaimed "Newtons out, Newton's out!"

Newton said "No, I'm not out as I'm not Newton!"

All the other scientists now left their hiding places and demanded that he proved that he was not Newton.

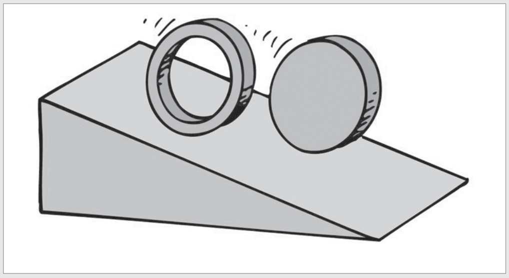
Newton said: "I am standing in a square of area 1 metre square. That means I am Newton per metre square. Hence I am Pascal as 1 Newton per square metre = 1 Pascal!"

From https://sites.google.com/site/b2222w/home/science-puzzles-and-jokes

Did you know?

At the same time a ball of iron and a ball of wood of equal size are rolled down a slope from the top. Can you guess which of the two will reach the bottom first? Answer: Both will reach the ground at the same time, if we assume that the friction is negligible.

Now, suppose you have a solid cylinder of wood and a hoop of iron, both of the same mass and same outer radius. Which of the two will be down first? Do write in and let us know.



Answer to "Deadly Choice

The man says, "I will be killed by trampling of wild buffalo."

If you think about it carefully: the King can't say it is true, because if so the man should be killed by the lions. But if he is killed by the lions, then his statement would be false, and so should have been trampled by buffalo.

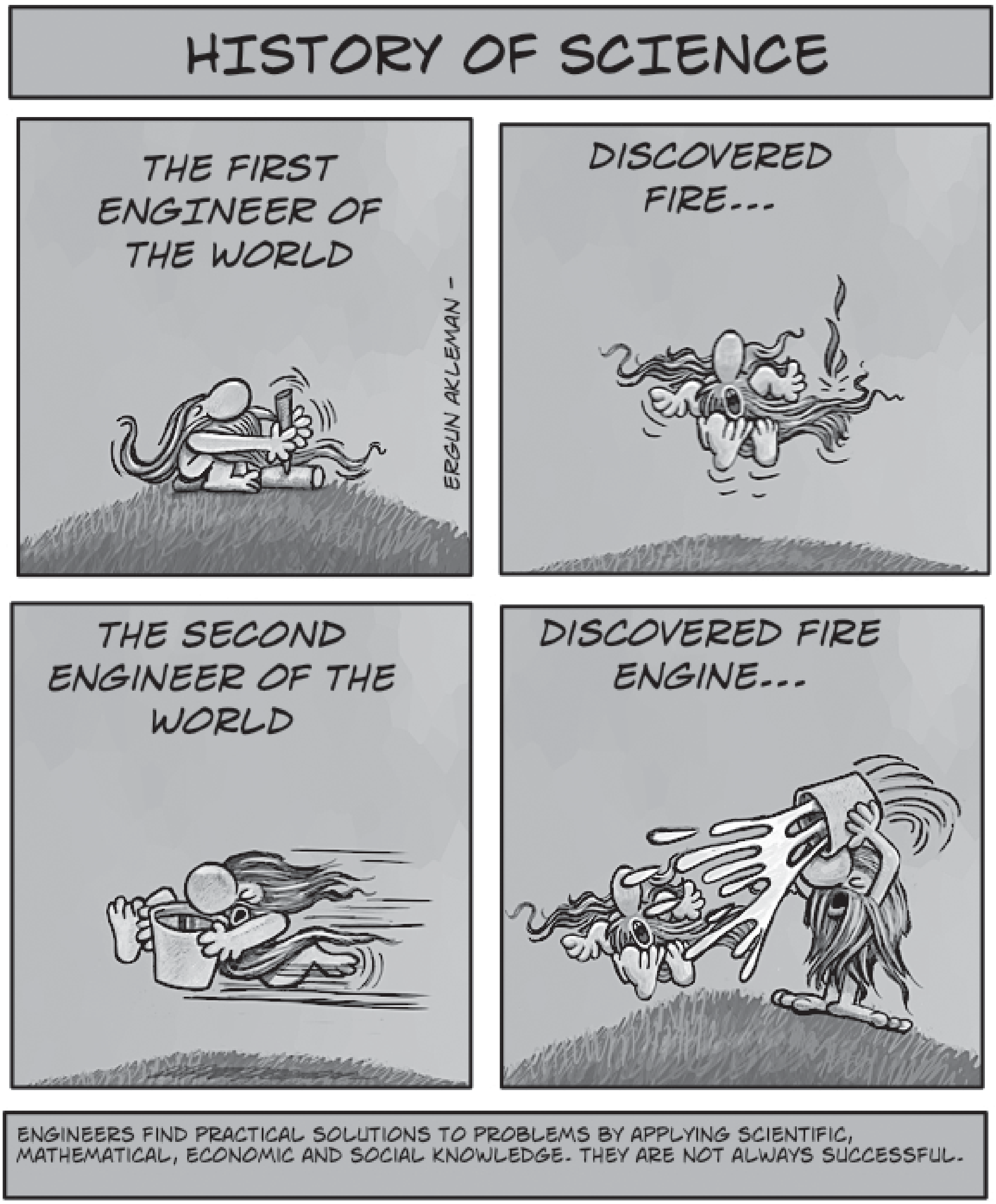
So the King can't tell if it is a lie or truth, so decides to just let him go.

There are other possible solutions. Can you think of any?

--From Math is Fun, http:www.mathisfun.com

MADmatic

Ergun Akleman



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